

New Observations, Period, and Classification of V552 Cassiopeiae

Emil J. L. Pellett

(Student at James Madison Memorial High School, Madison, Wisconsin), Yerkes Observatory, Williams Bay, WI 53191;
emil.pellett@live.com

Received October 9, 2018; revised November 1, 2018; accepted November 1, 2018

Abstract V552 Cas is a star yet to be systematically studied in the constellation Cassiopeia. The star was first indicated as a RR Lyr star by Götz and Wenzel (1956). The results presented in this paper convincingly demonstrate V552 Cas is a β Lyrae (EB) type eclipsing binary star with a period of 1.32808 days.

1. Introduction

Yerkes Observatory has a long history of astronomy education through outreach programs for both college and high school students. One of those programs, the McQuown Scholars program, allows high school students to conduct their own astronomical research through access to the Skynet system of robotic telescopes as well as the Stone Edge Observatory, with the support and supervision of experienced astronomers. The results presented in this paper were obtained as part of a McQuown Scholars project.

The variable star V552 Cas, located at R.A. $01^{\text{h}} 05^{\text{m}} 18.70^{\text{s}}$, Dec. $+63^{\circ} 21' 24.7''$ (2000), was discovered in 1956 as part of the Sonneberg Observatory surveys, but has not been systematically studied. Based on the original observations, V552 Cas was classified as a RR Lyrae (RRAB) type variable star in the *General Catalogue of Variable Stars* (GCVS; Samus *et al.* 2017). V552 Cas has been further studied by the WISE satellite and was found to be a RRAB variable star with a period of 0.64 ± 0.005 day (Gavrilchenko *et al.* 2014). The AAVSO International Database (AID) reports no observations of V552 Cas, and the AAVSO Photometric All Sky Survey (APASS; Henden *et al.* 2016) gives only two observations which show no variability.

V552 Cas was originally described in Götz and Wenzel (1956), who designated it as S 3873. Based on the observations taken from the few available plates at the time, the authors concluded that S 3873 was possibly a RR Lyrae type star, even though it had been first indicated as an Algol type star (see note in Götz and Wenzel 1956, p. 311). A more exact statement could not be made because insufficient data were available (Götz and Wenzel 1956). Based on this publication, the GCVS lists V552 Cas as a RRAB type variable star. A finder chart is provided by the Sonneberg Observatory (see http://www.4pisysteme.de/obs/pub/mvs/MVS_Volume_01.pdf page 291).

This report describes the first systematic study of V552 Cas. The presented results indicate V552 Cas should be classified as a β Lyrae (EB) type eclipsing binary star, not a RRAB type variable star.

2. Observations

Observations of V552 Cas were taken over 17 nights from August 2017 through February 2018 with a 20-inch (51-cm), $f/8.1$, Cassegrain telescope at Stone Edge Observatory in California (observatory code G52). The observations were made with a Finger Lakes Instrumentation PROLINE PL230 CCD camera. A binning of 2×2 was used which yielded a 26 by 26 arc-minute field of view and a 1.4 arc-second per pixel scale. The *i*, *r*, and *g* filters from the Sloan Digital Sky Survey's (SDSS) filter system were used for the observations.

A total of 2,576 images were obtained. Images with obvious defects (e.g., satellite trails through stars to be measured, light contamination from car headlights, variable cloud cover) were excluded from the final data set, leaving a total of 2,043 images that were analyzed. The images were processed using bias and flat frames taken on the same night and with dark frames taken by the observatory within the same week. The darks were scaled down from a 120-second exposure to the 70 seconds used for the exposures of V552 Cas.

Photometry of the processed images was performed with the SOURCE EXTRACTOR software (Bertin and Arnouts 1996) using a 5-pixel aperture radius. The default detection threshold of 1.5σ was sufficient to detect the required stars. The software calculated the sky background of the image. The full description of how SOURCE EXTRACTOR creates a background map can be found in section 7 of the user manual (see <https://www.astromatic.net/pubsvn/software/sextractor/trunk/doc/sextractor.pdf>). Differential magnitudes were calculated for V552 Cas and a check star against a comparison star of similar color to

Table 1. The position and color of the variable and comparison stars.

Star	R.A. (2000) h m s	Dec. (2000) ° ' "	Color (B-V)
V552 Cas	01 05 18.70	+63 21 24.700	0.760
2MASS 01050480+6320565 (check)	01 05 04.809	+63 20 56.576	0.939
2MASS 01053262+6322391 (comparison)	01 05 32.628	+63 22 39.148	0.792

V552 Cas. See Table 1 for details. The differential magnitudes were zero pointed using the magnitude of the comparison star as found in APASS (Henden *et al.* 2016). The CCD observations have been deposited in the AAVSO International Database under “V552 Cas.”

3. Analysis

A preliminary look at the first night’s light curve showed a time of nearly constant brightness followed by a deep drop. This suggested the star might be an eclipsing binary with a period of around one day rather than a RR Lyrae. Observations on further nights confirmed the eclipsing nature of the star. A period search on all the acquired data was done using the AAVSO VSTAR DC DFT task (Benn 2012), searching for periodicities in the range 0.2 to 2.0 days with a resolution of 0.00001 day. A clear periodicity of 0.66409 day was found, as shown in Figure 1. Taking into account the need for primary and secondary minima, which are of almost equal depth, the true period should be about twice the derived value.

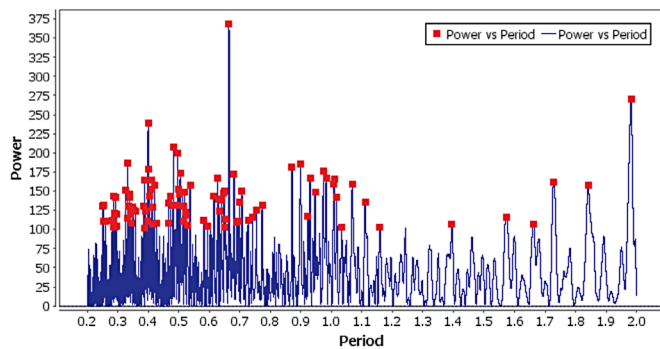


Figure 1. The power spectrum of V552 Cas for periods in the range 0.2 to 2.0 days.

A period of 1.32808 days was found to best fit all the data. Figure 2 shows the phased light curves plotted with this period for the three observed filters. The ephemeris used was:

$$\text{Modified Julian Date (MJD) of Primary Eclipse in r-band} = 57991.29571 + 1.32808 E.$$

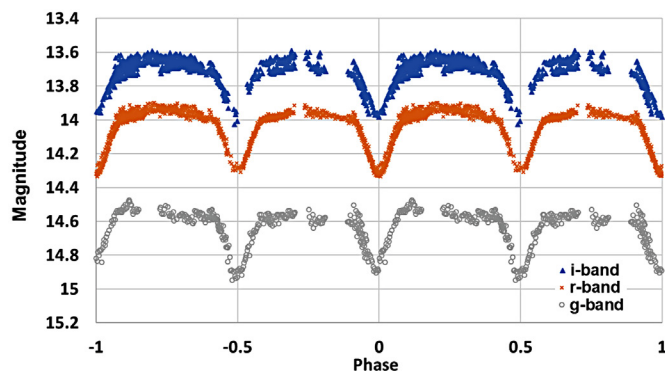


Figure 2. The phased light curve of V552 Cas with an Epoch (MJD) of 57991.29571.

Figure 3 shows the light curves for the check star, which are constant with a scatter of about 0.03 magnitude, which can be taken as the error of a single observation.

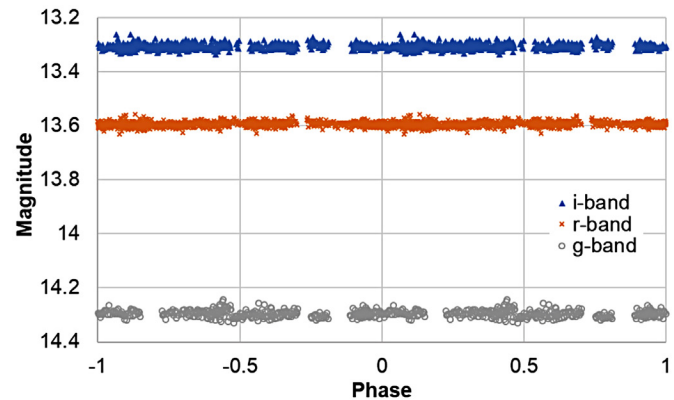


Figure 3. The phased light curve of the check star with the Epoch (MJD) of 57991.29571.

Examining the variable’s light curves clearly shows that there are two minima of different depths and the more constant area is curved—not flat—showing V552 Cas is an EB type eclipsing binary star. Surprisingly, the deepest minima in the r data corresponds with the shallowest minima of the i and g data. No definitive explanation for this could be found. The eclipse depth of the deepest minima in the i filter is 0.37 magnitude, in the r filter 0.40, and in the g filter 0.36. It should also be noted that the out-of-eclipse light curves are not symmetrical, which is a strong sign of star spot activity, as is typical for RS CVn systems. This could be one possible explanation for the observed discrepancies in the eclipse depths in the SDSS i, r, and g filters. A detailed light curve analysis will be required to examine this hypothesis.

4. Summary and conclusions

Based on the presented data, V552 Cas has a variation of 0.45 magnitude in brightness and a period of 1.32808 days. V552 Cas should now be classified as an EB eclipsing binary star in accordance with the definitions presented by the GCVS.

5. Acknowledgements

A huge thank you is due to Dr. Wayne Osborn, the author’s guide and mentor, without whom this work would have been impossible. A thank you is due to Yerkes Observatory and Kate Meredith for allowing use of its resources through the McQuown Scholars Program. The author also thanks Matt Nowinski, Amanda Pagul, Tyler Linder, and Marc Berthoud for their help and teaching.

References

- Benn D. 2012, *J. Amer. Assoc. Var. Star Obs.*, **40**, 852.
- Bertin, E., and Arnouts, S. 1996, *Astron. Astrophys., Suppl. Ser.*, **117**, 393.
- Gavrilchenko, T., Klein, C. R., Bloom, J. S., and Richards, J. W. 2014, *Mon. Not. Roy. Astron. Soc.*, **441**, 715.
- Götz, W., and Wenzel, W. 1956, *Veröff. Sternw. Sonneberg*, **2**, 284.
- Henden, A. A., *et al.* 2016, AAVSO Photometric All-Sky Survey, data release 9 (<http://www.aavso.org/apass>).
- Samus N. N., Kazarovets E. V., Durlevich O. V., Kireeva N. N., and Pastukhova E. N. 2017, *General Catalogue of Variable Stars*, version GCVS 5.1, in *Astro. Rep.*, **61**, 80 (<http://www.sai.msu.su/gcvs/gcvs/index.htm>).