A New Candidate δ Scuti Star in Centaurus: HD 121191

Roy A. Axelsen
P. O. Box 706, Kenmore Qld 4069, Australia; reaxelsen@gmail.com

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Abstract During a study of the δ Scuti star V1393 Centauri by digital single lens reflex photometry, it was found that two of the chosen comparison stars were variable. This paper reports the subsequent investigation of one of them, the class A star HD 121191, which revealed that it is a candidate δ Scuti star with a period of 0.046282 d and an amplitude of 0.048 magnitude in V.

1. Introduction

δ Scuti stars are pulsating variables with short periods and mostly low amplitudes. They comprise about one third of A5-F2 III-V stars (Percy 2007). Amateur astronomers performing time series photometry occasionally discover previously unrecognized δ Scuti-like periods (Moriarty *et al.* 2013). This paper reports one such discovery. While performing time series DSLR photometry on the δ Scuti star V1393 Cen, the author found that two of the chosen comparison stars were variable. As no AAVSO finder charts were available for V1393 Cen at the time of the observations, the author simply chose what appeared to be appropriate comparison stars, after checking in SIMBAD (Wenger *et al.* 2000) and the *General Catalogue of Variable Stars* (GCVS; Samus *et al.* 2017) that they were not reported as variable. However, after check star light curves showed obvious variability, observations were concentrated on two new variables. This paper reports the results of the study of one of them, HD 121191, an A5 IV/V star (Melis *et al.* 2013) in Centaurus with coordinates (J2000) R.A. 13^h 57^m 56.44^s Dec. –53° 42' 15.34" (ICRS coordinates, SIMBAD astronomical database).

2. Methods

Time series photometry was performed on five consecutive nights from 26 to 31 May 2019. Images were taken with a Canon EOS 500D digital single lens reflex (DSLR) camera through an 80mm f/7.5 refractor on an equatorial mount. Exposures of 180 seconds were taken at ISO 400, with a 5-second gap between consecutive exposures. Autoguiding was performed by the software PHD2 GUIDING, with an Orion StarShoot Autoguider imaging through an 80 mm f/5 refractor.

Images were converted to the FITS format and pre-processed in IRIS (Buil 1999–2018) using dark, bias, and flat frames, and images from the blue and green channels were extracted. The latter images were imported into ASTROIMAGEJ (Collins *et al.* 2017) for aligning and aperture photometry. Comparison and check stars were HD 120858 and HD 121277, respectively. Values of V and B–V for the comparison star were taken to be 8.706 and 1.356. For the check star, the corresponding values were taken to be 9.162 and 1.234. HD 121191 (the new variable) has a magnitude in V of approximately 8.17 and a B–V color index of approximately 0.24. These V and B–V values were taken from the planetarium program GUIDE 9.0 (Project Pluto 1996–2016). The author has found that V and B-V values in GUIDE 9.0 differ very little from those of standard stars from the E regions (Menzies *et al.* 1989), and are thus considered adequate for the purposes of this study.

Flux values from ASTROIMAGEJ were imported into an EXCEL spreadsheet. Instrumental magnitudes and transformed magnitudes in B and V were calculated, using transformation coefficients derived from images of standard stars from the E regions (Menzies *et al.* 1989). Atmospheric extinction coefficients were not used. B magnitudes were used only for the determination of the transformation coefficients, and for the calculation of transformed V magnitudes of the variable. As the precision of B magnitudes determined by DSLR photometry for the variable star is less than that for V magnitudes, the former are not reported in this paper.

The data were analyzed in VSTAR (Benn 2013) and in PERIOD04 (Lenz and Breger 2005).

3. Results

The transformed V magnitude of HD 121191 was determined for 653 time points over the five nights of observation. The light curve for one night is shown in Figure 1. The average B–V color index of HD 121191 over the five nights was calculated to be 0.233, very close to the B–V value of 0.243 as published in GUIDE 9.0.

A DCDFT (Date Compensated Discrete Fourier Transform) applied to the data in VSTAR revealed a frequency of 21.603 c d^{-1} corresponding to a period of 0.046291 d. The power spectrum from this analysis (Figure 2) shows this frequency and four other nearby labelled frequencies, with the latter representing one cycle per day aliasing due to the periodicity inherent in the nightly observation sets. ANOVA applied to binned means of the VSTAR residuals (0.04 phase step per bin) revealed an F-value of 0.6180 on 25 and 627 degrees of freedom with a p value of 0.9278. These results indicate that no further periods could be found within these data. A phase plot based on the period 0.046291 d is shown in Figure 3.

The mathematical output of the model created in VSTAR is:

$$f(t{:}real){:}\ real\ \{8.182428 + 0.023603 * \cos(2*PI*21.602471*(t-2458632.1)) + 0.004152 * \sin(2*PI*21.602471*(t-2458632.1))\} \quad (1)$$

Fourier analysis was also performed in the period analysis software PERIOD04 and revealed a frequency of 21.607 (±002) c d^{-1}, corresponding to a period of 0.046282 (± 0.000004) d. This period is 0.000009 d shorter than that found in VSTAR, but is so close that it is considered to be the same period. The signal-

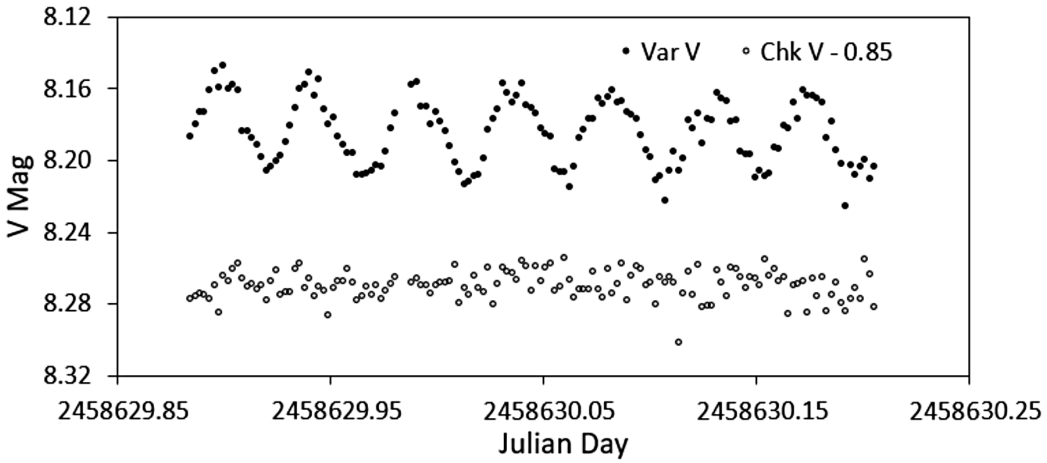

Figure 1. The light curves of the variable star HD 121191 and the check star HD 121277 obtained by DSLR photometry during one night. Almost seven complete cycles of the variable star are evident. Var V = Variable star V magnitude. ChkV – 0.85 = Check star V magnitude minus 0.85.

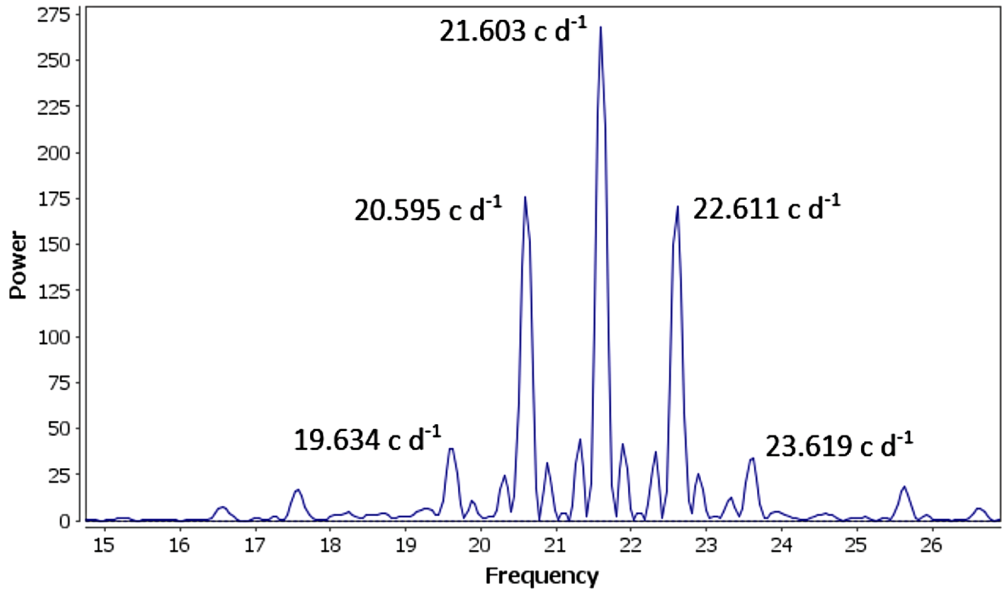

Figure 2. Power spectrum of the Date Compensated Discrete Fourier Transform from VSTAR. The frequency 21.603 c d^{-1} is accompanied by four other nearby labelled frequencies representing one cycle per day aliasing.

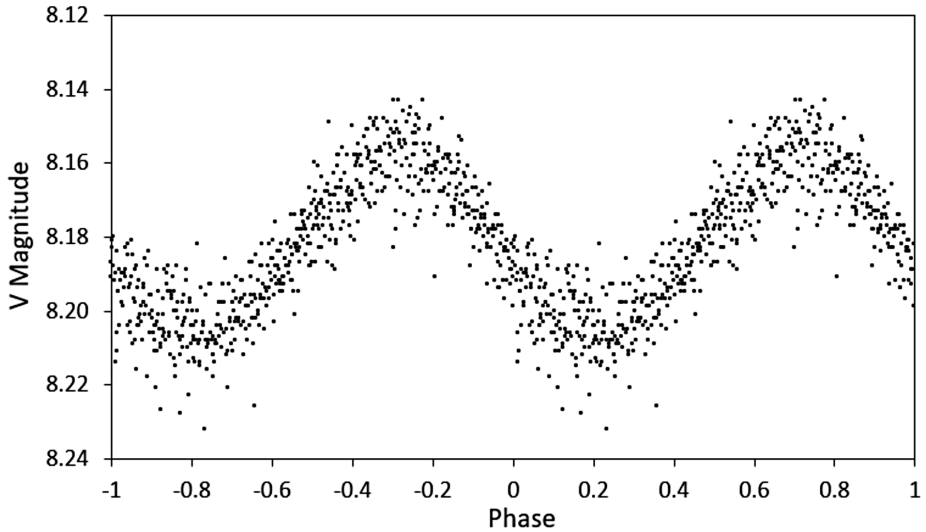

Figure 3. Phase plot of HD 121191 over two complete cycles, based on a period of 0.046291 d, created from data captured during five nights of DSLR photometry.

to-noise ratio for a box size of 2 is 3.01, somewhat low for an acceptable result, which should be at least 4.

4. Discussion

The purpose of this paper is to report an example of δ Scuti-like variability which has apparently not been recognized previously. The basis for this statement is that identity and position searches (i.e., R.A. and Dec.) in SIMBAD, and position searches in the *General Catalogue of Variable Stars* and through the SAO/NASA ADS Astronomy Query Form (http://adsabs.harvard.edu/abstract_service.html) failed to find any specific reference to the target star HD 121191.

The facts that HD 121191 is an A type star (Melis *et al.* 2013) exhibiting stable variability with a period of just over one hour, and that the amplitude is just under 0.05 magnitude in V, suggest that the variability is of δ Scuti type.

The circumstances of the discovery of the variability emphasize the well-known necessity of employing comparison and check stars in differential photometry, and flag the need to be confident of the absence of variability in comparison stars used in ensemble photometry. As shown herein, it is not sufficient to note the absence of candidate comparison stars from catalogues of variable stars, and from bibliographic databases which should contain reports of stellar variability. Although the averaging process in ensemble photometry reduces the final error, it is patently not acceptable to employ as a comparison star for photometry one which exhibits variability with an amplitude of just under 50 millimagnitudes.

Finally, it should be noted that the precision of DSLR time series photometry of an eighth-magnitude star using equipment employed in the present study is not optimal for the investigation of low amplitude δ Scuti-like variability. The superior precision and faster cadences achievable using CCD photometry would be preferable. However, it is clear that even the lesser precision of photometry using a DSLR camera is sufficient for valid discovery information to be documented.

5. Conclusion

The A type star HD 121191 is proposed as a new candidate δ Scuti variable, with a period of 0.046282 d and an amplitude of 0.048 magnitude in V. The discovery of this variability was made serendipitously during DSLR photometric studies of another known δ Scuti variable.

6. Acknowledgements

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References

Benn, D. 2013, VSTAR data analysis software (http://www.aavso.org/vstar-overview).

Buil, C. 1999–2018, IRIS astronomical images processing software (http://www.astrosurf.com/buil/iris-software.html).

Collins, K. A., Kielkopf, J. F., Stassun, K. G., and Hessman, F. V. 2017, *Astron. J.*, **153**, 77.

Lenz, P., and Breger, M. 2005, *Commun. Asteroseismology*, **146**, 53.

Melis, C., Zuckerman, B., Rhee, J. H., Song, I., Murphy, S. J., and Bessell, M. S. 2013, *Astrophys. J.*, **778**, 12.

Menzies, J. W., Cousins, A. W. J., Banfield, R. M., and Laing, J. D. 1989, *S. Afr. Astron. Obs. Circ.*, **13**, 1.

Moriarty, D. J. W., Bohlsen, T., Heathcote, B., Richards, T., and Streamer, M. 2013, *J. Amer. Assoc. Var. Star Obs.*, **41**, 182.

Percy, J. R. 2007, *Understanding Variable Stars*, Cambridge University Press, Toronto, 183.

Project Pluto. 1996–2016, GUIDE 9.0 planetarium software (www.projectpluto.com).

Samus, N. N., Kazarovets, E. V., Durlevich, O. V., Kireeva, N. N., and Pastukhova, E. N. 2017, *Astron. Rep.*, **61**, 80.

Wenger, M., *et al.* 2000, *Astron. Astrophys., Suppl. Ser.*, **143**, 9.