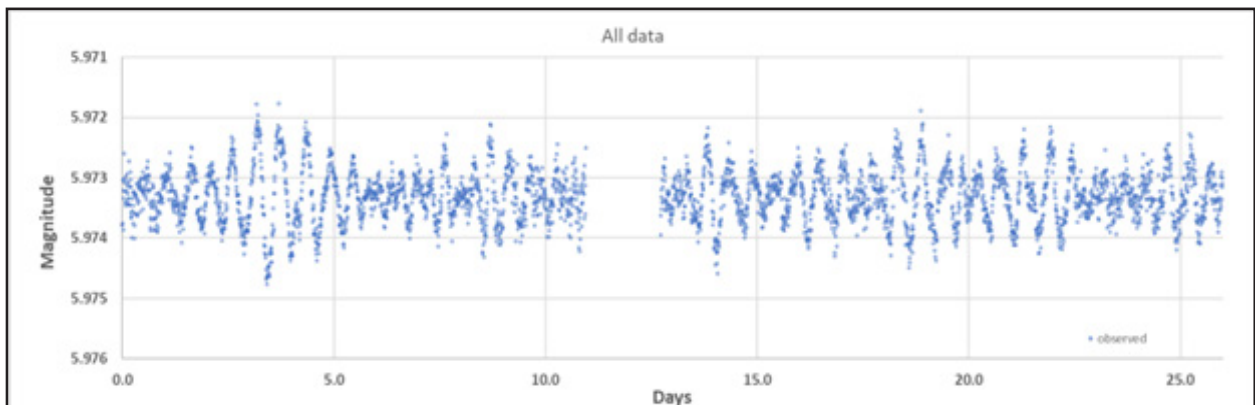
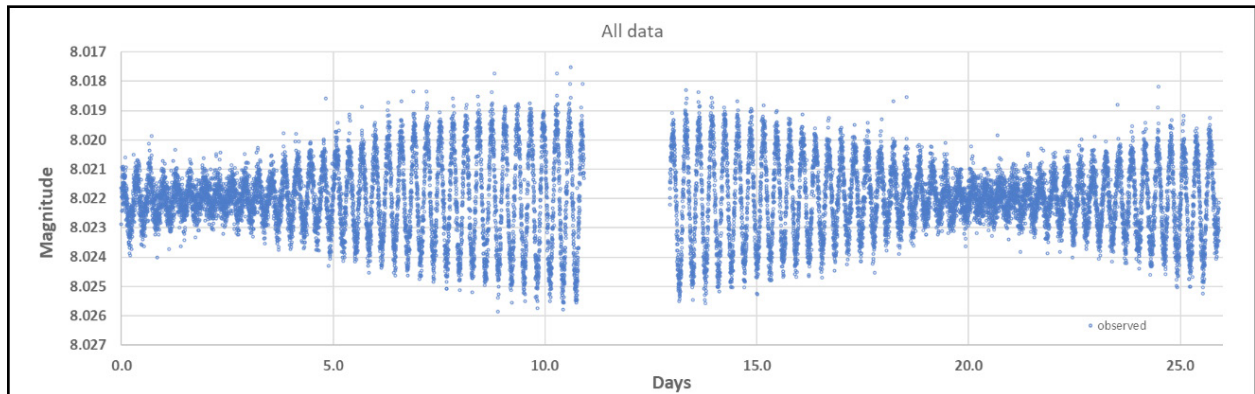




With its wide coverage of both hemispheres at 2 minute cadence NASA's TESS satellite has not only helped discover 66 confirmed exoplanets (to date) but it has also observed a large number of new variable stars. Mark Blackford reports on a frequency analysis of each of two such TESS variables - HD 36628 (TIC 50789967) and HD 36882 (TIC 427377510). The top graph shows TESS rapid (2 minutes) cadence during November and December 2020 for HD36628. The lower graph shows 10 minute cadence observations for HD26882 also during November and December 2020. See Mark's article on page 6 for full details.

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From the Director – *Mark Blackford*

Happy New Year and welcome to the first edition of the newsletter for 2023 and thank you to Roy Axelsen and Ed Budding for their contributions. In the last newsletter I announced the discovery of several new pulsating variable stars in the vicinity VV Orionis. In this issue I present frequency analyses of two of these, HD 36628 and HD 36882.

In early November Canadian astronomer Dr Robert H. Nelson, a prolific observer and author on eclipsing binary stars, passed away. Bob was very supportive of Variable Stars South and worked closely with several members. An obituary written by Robert Jenkins can be found on page 16 of this newsletter.



Back in September Arne Henden gave a fascinating presentation on the peculiar southern hemisphere star V838 Mon during the VSS virtual symposium. His slides and video recording are available at <https://www.variablestarssouth.org/community/events-and-presentations/sixth-vss-symposium/arne-henden>. Recently Arne announced a new AAVSO campaign on V838 Mon (<https://www.aavso.org/campaign-v838-mon>) that will be of interest to VSS photometrists. The campaign has very specific requirements aimed at achieving high quality transformed observations from multiple observers to monitor short- and long-term variations. Arne will provide advice to participants to help improve photometry skills.

Visual and electronic observers may also be interested in another initiative jointly sponsored by AAVSO and the SuperNova Early Warning System (SNEWS) project (<https://www.aavso.org/snews-campaign>). The campaign announcement states:

“The goal is to obtain long-term photometry of massive stars that might become supernova in the foreseeable future. Having a record of the star's behaviour previous to the explosion is very important in order to understand how supernovae work. Of course, the chances of any of these objects exploding as SN during our lifetimes are very low, but... who knows?”

Dr Bradley Schaefer has written an excellent article on recurrent nova for the AAVSO Cataclysmic Variables Section (<https://www.aavso.org/recurrent-nova-science-tasks-observers-worldwide>). In it he highlights six types of observations amateurs can make to help professional astronomers understand these rare objects. The good news for VSS members is all but one of the 10 known examples are southern hemisphere objects.

The 2023 RASNZ Conference will be held over Queens Birthday Weekend from June 2nd to the 4th, hosted by the Auckland Astronomical Society (AAS). Variable Stars South members are encouraged to present their research via oral or poster presentations. I plan to be there and would love to catch up with other variable star observers.

Bureau of Meteorology forecasts of wetter than usual conditions over spring and summer have proven to be accurate. At Congarinni Observatory I managed just 16 nights of observing in the last 3 months, and most of those were affected by cloudy periods.

Wishing you all clear skies and good health,

Mark Blackford

Lunar occultation of Mars: Did Aristotle miss a significant detail? – *Ed Budding*

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Abstract

Observational circumstances of lunar occultations of Mars are briefly reviewed, with particular reference to an example observed by Aristotle, and its potential significance to the development of astronomical science.

Lunar occultation of Mars

On Dec 7, 2022 a lunar occultation of the planet Mars occurred. This was visible in the early part of the night in parts of North America, though out of range for most of the world. The Moon was nearly full at the time, so timing details of the observation would not have been so easy. But unlike a stellar occultation, the disappearance of the light from Mars can take a number of seconds. Using the planetarium program *Stellarium*, I measured around 30 sec for the disappearance time at Winnipeg, where the Moon was seen to encounter Mars fairly centrally.

Occultation circumstances – rough calculation

Let the Moon travel in its orbit at M arcsec/sec and Mars m arcsec/sec, i.e. the Moon's eastwardly apparent motion towards Mars is then $M - m$. The Moon completes its orbit (of 360 deg) in a month, or about 13 deg/day; whereas the orbital motion of Mars on the sky is about 0.5 deg/day (Allen, 1974). This means that, in a first approximation, we can neglect the apparent orbital motion of Mars, and so the relative motion into the lunar occultation is about 0.55 arcsec/sec. If an immersion event lasted about 10 sec, say, it would imply an apparent diameter of Mars to be about 5.5 arcsec.

Suppose now Mars is a similar body to the Earth having, say, ~6500 km radius, then in order to show the 5.5 arcsec angular diameter the planet would have to be distant $13000 \times (206265/5.5)$ or ~ 500 Mkm. In fact, Mars has about 1/2 the diameter of the Earth; so the planet would have to be ~ 250 Mkm distant at the time of the observation. In this way, we can get some 'feel' for the scale of planetary separations even without any detailed knowledge of their nature or properties. Such distances may be contrasted with that of the Moon of around 0.4 Mkm.

Aristotle's astronomy

In his account of contemporary astronomical knowledge -- the *De caelo* ('On the Heavens', ~350 BC) -- Aristotle refers to an observation he made of a lunar occultation of the planet Mars. Arguing that the planetary system must be on a greater scale than the Earth-Moon system, he wrote "For we have seen the Moon, half full, pass beneath the planet Mars, which vanished on its shadow side and came forth by the bright and shining part."

Efforts to trace this observation go back at least as far as Johannes Kepler, who published in his *Astronomia nova* (1609) that this event should have been on April 4, 357 BC. Kepler's date has been checked by later, more sophisticated, computational methods and found to be out by (interestingly) exactly one calendar month. F R Stephenson (2000), confirmed that only one occurrence fit the facts, and this occurred at about 7h 40 pm, Athens local time, on the evening of May 4, 357 BC. The complete event was as Aristotle described with the emergence happening at about 9h 15 pm. The distance of Mars at the time, using Stephenson's longitude, was ~1.7 AU or ~250 Mkm. From the foregoing, then, the ingress should have lasted about 10 sec.

At the date in question Aristotle, then aged about 27, would have been in a 'postdoc' type situation at the original Akademia in Athens. Yet to make his own name, he would have been influenced by some of the leading thinkers of the time, including Eudoxus of Cnidos, a renowned mathematician and theoretician.

cian of astronomy. Eudoxus had produced a model of the solar system, which involved a number of interlocking spheres with independent rotation axes. Plato, head and founder of the Akademia, had previously issued a challenge for such a model to be constructed and Eudoxus, who had travelled far to visit astronomical establishments of the age, would have been well placed to respond. *De caelo* shows that Aristotle had studied this model. He had also probably learned of the relatively well-developed astronomical knowledge of the Babylonian school from Eudoxus.

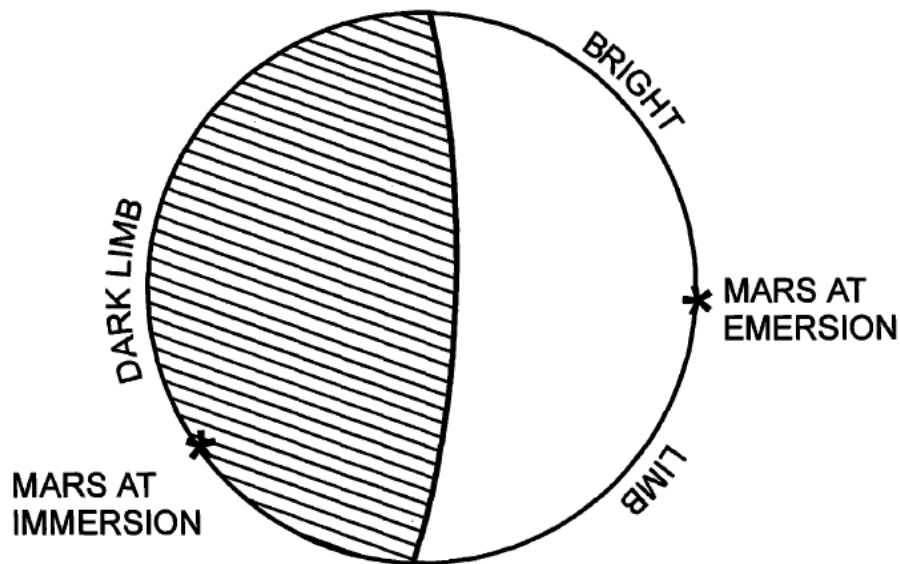


Figure 1. Occultation of Mars by the Moon as seen from Athens on the evening of 4 May 357 BC and reported by Aristotle in *De caelo* (according to Stephenson, 2000).

Eudoxus and Aristotle could have worked out the approximate distance of the Moon from a few elementary geometrical considerations. Thus, in *De caelo*, Aristotle notes, from estimating the radius of curvature of the shadow during lunar eclipses, that the Moon's radius is about $\frac{1}{4}$ that of the Earth. This estimate requires that the Sun is quite more distant than the Moon, and, from more elaborate considerations of the data on eclipses, Eudoxus had deduced that the Sun was about twenty times the distance of the Moon, allowing Aristotle's estimate to carry a fair validity, even if the Earth-Sun separation was still only poorly known (for background, see e.g. Gamow, 1947).

The radius of the Earth had been evaluated approximately from the fact that the maximum altitude of the Sun at the summer solstice depends on latitude. Thus, it was known that near the location of Philae, in the south of Egypt, the Sun rose to the zenith at the summer solstice, while at Heliopolis, around 800 km to the north (a known distance), it reached only to 83 deg altitude. From such data the size of the Moon could be estimated to be about 1600 km in radius. To appear as a disk of $\frac{1}{2}$ deg angular diameter, a distance of ~ 0.4 Mkm is implied.

In *De caelo*, Aristotle remarks that the stars are much further away than the planets, because the former, unlike the latter, twinkle. This idea, although linked to an obsolete model of vision, may have been verifiable from observations of the night-time *phryktoriae*, or system of hill-top warning beacons used in ancient times to transmit urgent messages quickly to distant places. The separation of the beacons could reach to tens of km, at which distance they would become unresolved by the eye and subject to scintillation. The increasing faintness of a beacon with distance would have surely been common knowledge, though it is too much to expect any quantitative assessment of such effects. Even so, taking into account the illumination conditions of both Moon and Earth and the visibility of the planets, it could be deduced that the planets shine with the reflected light of the Sun rather than their own incandescence. The Moon and planets could have been reasonably taken to be basically Earth-like worlds.

A missing element in this discussion concerns the measurement of time. The division of the day into hours derives from the Babylonian astronomy that preceded the Hellenistic one (van der Waerden, 1949), but it was known to Eudoxus. The division of the hour into 60 ‘first’ small divisions (minutes) is also of Babylonian origin. The approximate equality of the normal healthy resting pulse interval to a ‘second’ sixtieth division may have been noticed by the Babylonians. That is a plausible speculation, but I have found no evidence for it.

The point here, though, is that, given the lunar angular speed (Section 2), planetary occultation timings can be translated into angular sizes that would have been far too small to measure in the pre-telescopic era. Had Aristotle indicated that the immersion lasted for about 10 heartbeats it could have been used to determine the size of the planet, given an adopted estimate of the size of the astronomical unit. But what about the disparity between Aristotle’s (hypothetical) timing and the 30 sec of the Dec 2022 event? The wide variation in the separation of Earth and Mars naturally explains such timing variations on the heliocentric model, whereas it becomes a problem for Aristotelian cosmology, where the apparent angular diameters of planets should be nearly constant.

Conclusion

Stephenson (2000) had “no hesitation” in supporting the derived observational circumstances of the occultation of Mars reported by Aristotle in *De caelo*. An approximate representation of the geometry of the occasion indicates that the (more easily measurable) immersion phase should have lasted about 10 seconds. However, this is strongly dependent on the elongation from the Sun, which Stephenson gave as 83 deg. Near to opposition, the duration can increase by three times this value. Had Aristotle given a reference figure for the immersion duration it could have become an important discriminant in the Sun or Earth-centred cosmological discussion with subsequent data collection. Aristotle’s simple deduction that the lunar occultation of Mars of May 4, 357 BC proved the planet to be more distant from the Earth than the Moon is in keeping with the Hellenistic philosophers’ interests concerning materialistic explanations of nature. However, the absence of further details in the record tends to favour the claim that the famous thinkers of those times had not yet realized the full weight of *data* in support of the development of theory.

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Frequency analysis of HD 36628 and HD 36882: two newly discovered pulsating variables in Orion – *Mark Blackford*

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Introduction

In the October 2022 edition of the VSS Newsletter I announced the discovery of several new variable stars near the eclipsing binary VV Orionis (Blackford, 2022a), including HD 36628 and HD 36882. The TESS light curves of both show pulsations of less than 10mmag total amplitude. Below I present the results of frequency analysis of these two stars and tentatively identify the type of pulsating variable in the case of HD 36628.

HD 36628 (TIC 50789967)

According to the SIMBAD database (<http://simbad.cds.unistra.fr/simbad/>) HD 36628 is an 8th magnitude star of spectral type B9 IV/V. It was observed by the TESS satellite in Sector 32 at 2-minute cadence between November 20th and December 16th, 2020. For this analysis I used the PDCSAP version of the TESS data, see (Blackford, 2021) for a description. The PDCSAP light curve displays a beating pattern due to the superposition of two dominant pulsation frequencies (Figure 1).

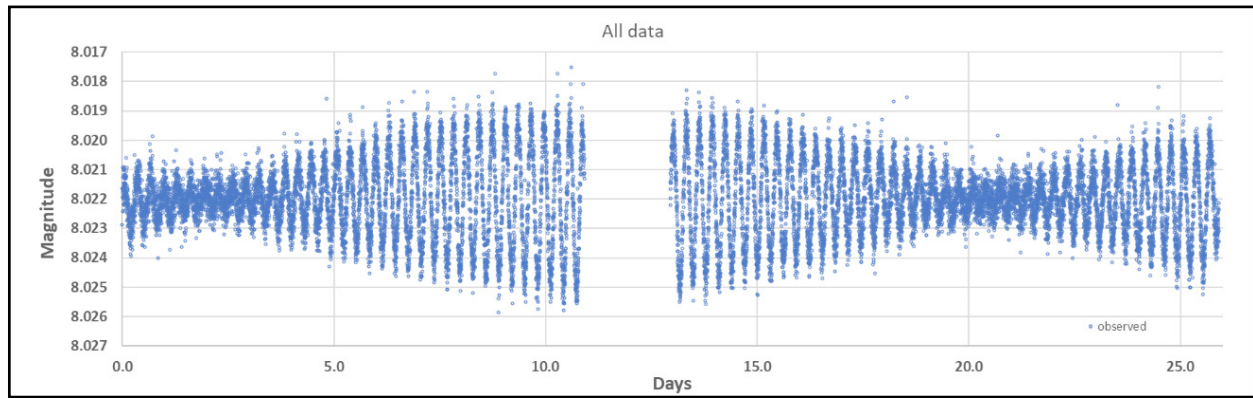


Figure 1. HD 36628 TESS 2-minute cadence observations between 20/11/2020 to 16/12/2020).

Frequency analysis using Period04 software (Lenz & Breger, 2004) yielded 4 frequencies with amplitudes that exceed four times the local noise level in the amplitude spectrum (table 1). Both F3 and F4 have amplitudes of 0.1 mmag or less. F4 is likely to be the first harmonic of F2 as it is very nearly twice the frequency. F3 may be an artefact of conditioning the TESS data to produce the PDCSAP light curve.

Table 1. HD 36628 Pulsation frequencies identified by Period04 software.

	Frequency (1/d)	Frequency sigma	Period (d)	Amplitude (mmag)	Amplitude sigma	Phase	Phase sigma	SNR
F1	3.248443	0.000078	0.307840	0.0015209	0.0000049	0.40812	0.00052	138.4
F2	3.302089	0.000093	0.302839	0.0012689	0.0000049	0.80310	0.00062	117.1
F3	0.080880	0.000996	12.364042	0.0001032	0.0000048	0.3058	0.0071	6.5
F4	6.602628	0.002106	0.151455	0.0000456	0.0000047	0.187	0.016	6.4

A model light curve was generated in Excel using all 4 frequencies, this is shown in orange in Figure 2 superimposed on the TESS light curve. Only 7 days are plotted to clearly show the excellent agreement between model and observations. Residuals after subtracting the model curve show no sign of structure as seen in Figure 3.

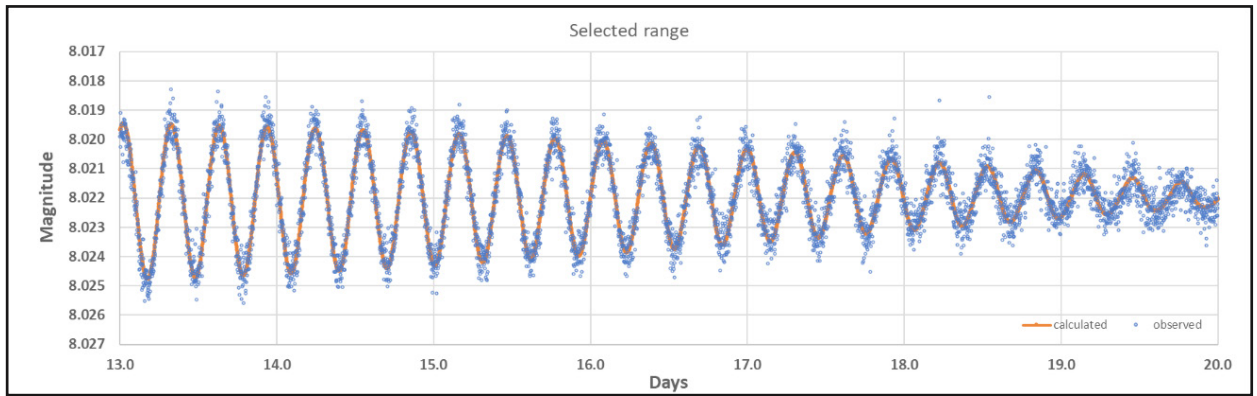


Figure 2. HD 36628 TESS light curve covering 7 days of observations with model curve in orange.

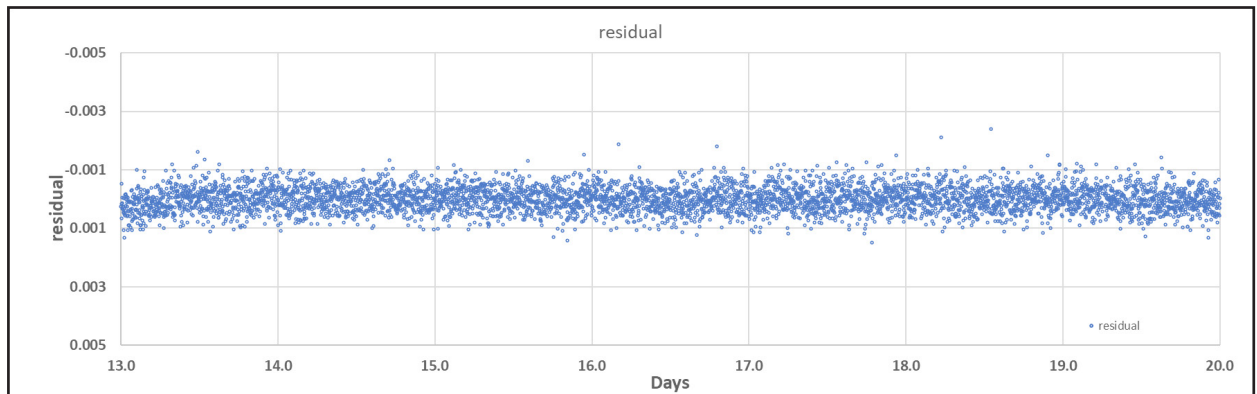


Figure 3. HD 36628 residuals after subtracting the model curve.

HD 36882 (TIC 427377510)

HD 36882 is an 7th magnitude star of spectral type K0 III according to the SIMBAD database. It too was observed by the TESS satellite in Sector 32 but at 10-minute cadence. The PDCSAP light curve (Figure 4) displays a more chaotic pattern due to multiple pulsation frequencies.

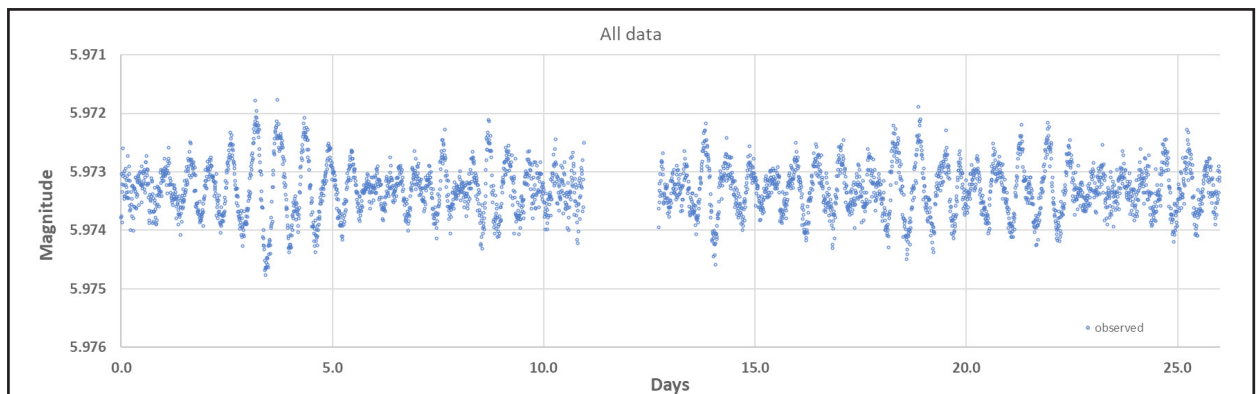


Figure 4. HD 36882 TESS 10-minute cadence observations between 20/11/2020 to 16/12/2020).

Period04 analysis found at least 20 significant frequencies (Table 2), each with sub-mmagnitude amplitude. A model light curve was generated in Excel using all 20 frequencies, this is shown in orange in Figure 5 superimposed on the first 10 days of the TESS light curve. The fit is reasonably good, however, residuals after subtracting the model show obvious structure (Figure 6) indicating further frequency analysis would be warranted.

Table 2. HD 36882 Pulsation frequencies identified by Period04 software.

	Frequency (1/d)	Frequency sigma	Period (d)	Amplitude (mmag)	Amplitude sigma	Phase	Phase sigma	SNR
F1	1.8262	0.0004	0.5476	0.0002565	0.0000052	0.7825	0.0033	19.6
F2	1.7154	0.0005	0.5829	0.0002440	0.0000052	0.2498	0.0034	19.5
F3	1.5870	0.0006	0.6301	0.0001711	0.0000052	0.7956	0.0049	15.0
F4	2.0367	0.0006	0.4910	0.0001729	0.0000052	0.3726	0.0048	11.5
F5	1.7785	0.0009	0.5623	0.0001224	0.0000052	0.2168	0.0068	9.6
F6	1.6426	0.0013	0.6088	0.0000845	0.0000052	0.7540	0.0099	7.1
F7	1.9792	0.0008	0.5053	0.0001390	0.0000052	0.2984	0.0060	9.4
F8	2.1887	0.0008	0.4569	0.0001467	0.0000052	0.6017	0.0057	9.3
F9	2.1322	0.0008	0.4690	0.0001370	0.0000052	0.2885	0.0061	8.9
F10	2.7743	0.0012	0.3605	0.0000947	0.0000052	0.4774	0.0088	5.7
F11	2.7196	0.0011	0.3677	0.0001035	0.0000052	0.9946	0.0080	6.3
F12	1.8515	0.0006	0.5401	0.0001881	0.0000052	0.8807	0.0045	14.2
F13	1.4884	0.0012	0.6719	0.0000921	0.0000052	0.2043	0.0091	8.8
F14	2.8472	0.0017	0.3512	0.0000639	0.0000052	0.3052	0.0130	3.7
F15	3.4359	0.0018	0.2910	0.0000622	0.0000052	0.8189	0.0134	3.2
F16	2.4150	0.0016	0.4141	0.0000706	0.0000052	0.7127	0.0118	4.3
F17	2.5164	0.0018	0.3974	0.0000612	0.0000052	0.6653	0.0136	3.8
F18	3.1071	0.0018	0.3218	0.0000610	0.0000052	0.8466	0.0137	3.3
F19	2.2736	0.0019	0.4398	0.0000595	0.0000052	0.6081	0.0140	3.6
F20	3.0082	0.0019	0.3324	0.0000578	0.0000052	0.6855	0.0144	3.1

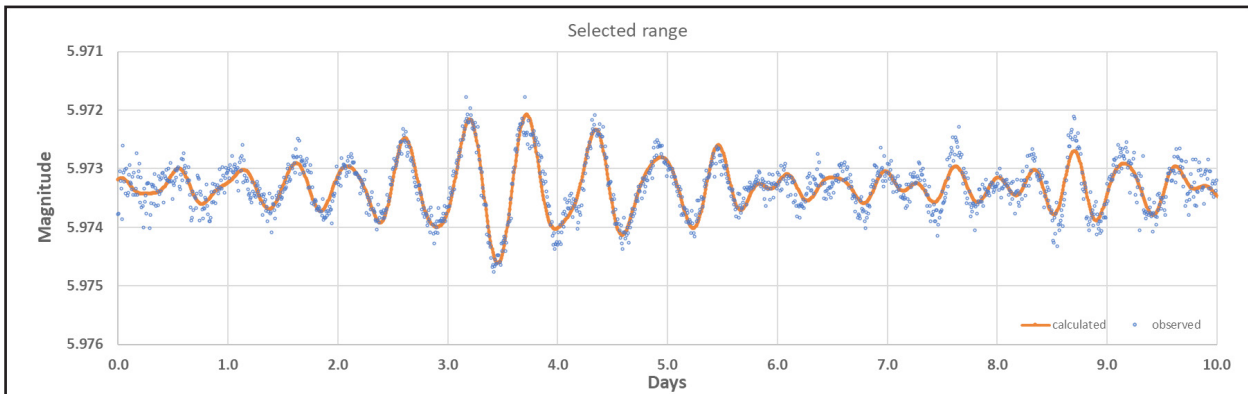


Figure 5. HD 36882 TESS light curve covering 10 days of observations with model curve in orange.

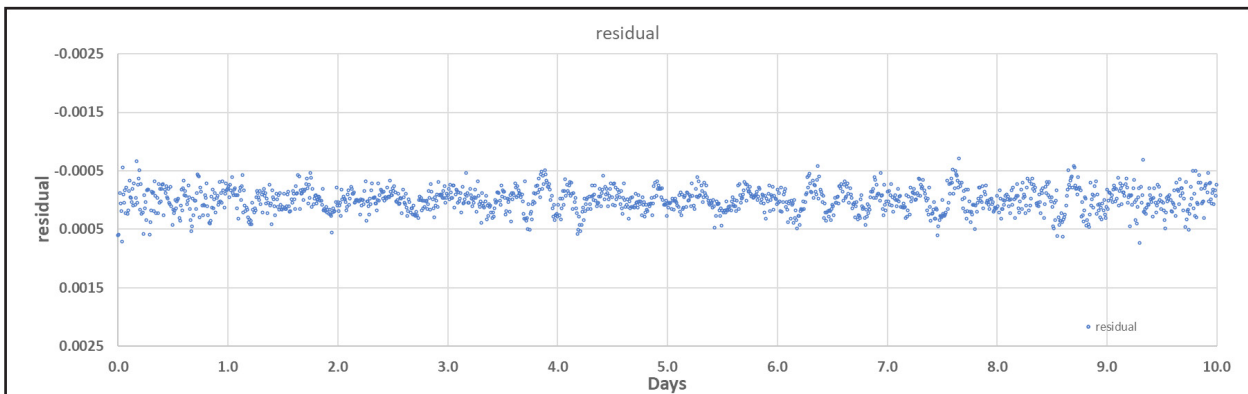


Figure 6. HD 36882 residuals after subtracting the model curve.

Discussion

I am by no means an expert on pulsating variable stars, so the following is mere speculation on my part. I would welcome responses from more knowledgeable people.

The position of different types of pulsating variables on the Hertzsprung-Russell diagram is shown in Figure 7. If the spectral classification of a star is known, we can use this diagram to identify the possible pulsator type.

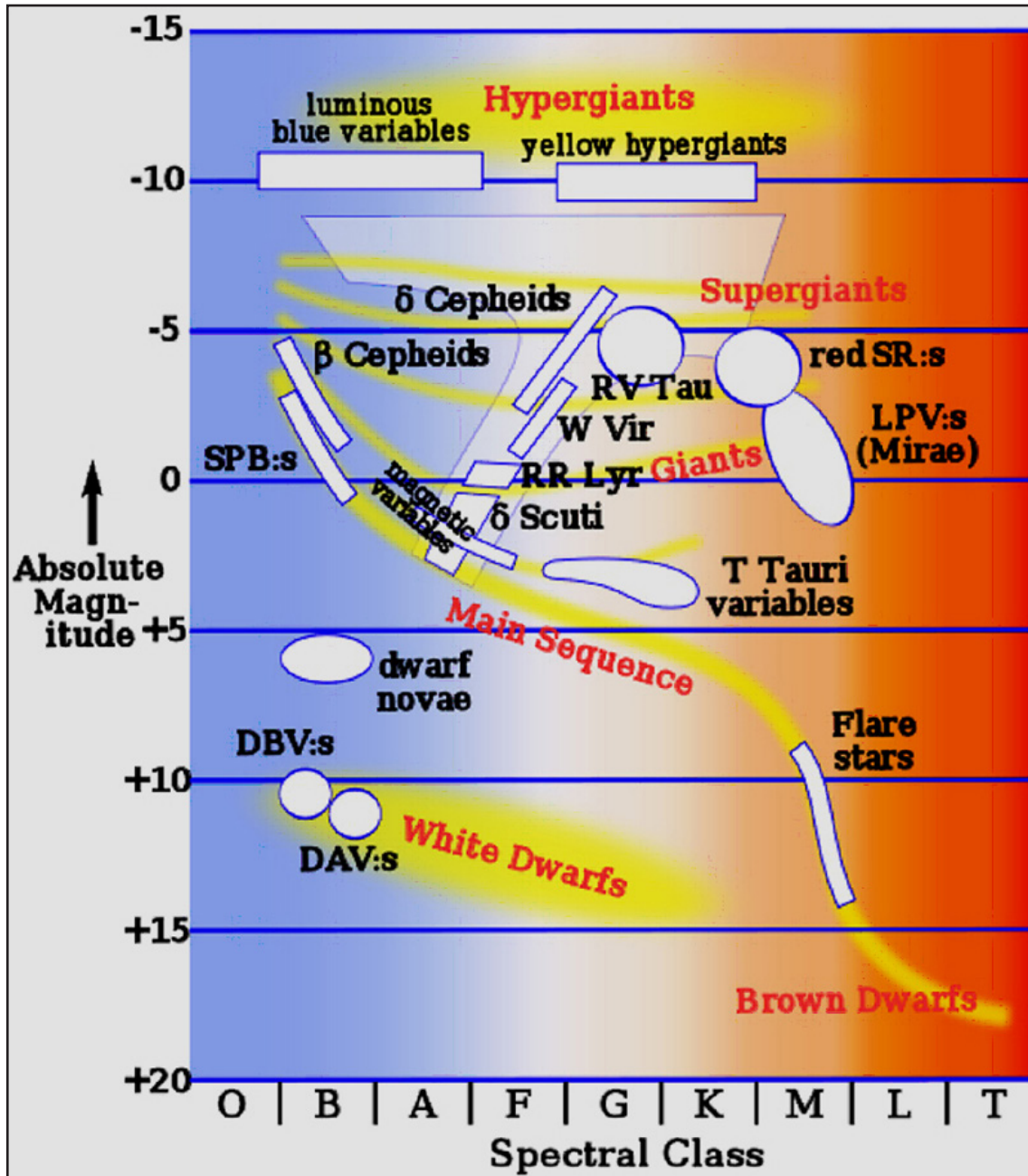


Figure 7. Pulsating Variable Stars and the Hertzsprung-Russell (H-R) Diagram (from CHANDRA X-Ray Observatory website).

As mentioned above HD 36628 is listed in SIMBAD as B9 IV/V, i.e., hot blue-white subgiant/main sequence star. From Figure 7 it may be either a β Cep or SPB:s type variable, however β Cep pulsators have a very narrow range of spectral types B2-3 IV/V. Which leaves SPB:s as the likely variable type for HD 36628. These slowly pulsating B-type stars are main-sequence stars of spectral type B2 to B9 (3 to 9 times as massive as the Sun) that pulsate with periods between approximately half a day and five days, however, most have been found to have multiple periods of oscillations.

SIMBAD lists HD 36882 as K0 III, i.e., a cool orange giant star. Inspection of Figure 7 suggests that it may be an RV Tauri type variable, however these have much larger magnitude ranges and periods of weeks to months. Could the spectral classification be wrong? This would seem unlikely for such a bright star. Perhaps the pulsations observed in the TESS light curve are from a background star that happens to be in the rather large measurement aperture of the TESS photometer. A third possibility is that these low amplitude pulsations are due to convection cells on the surface of this relatively cool star, so called solar-like oscillations. I'll leave it to others to figure out.

Conclusions

Pulsation analysis identified two dominant frequencies in the TESS light curve of HD 36628. It is likely to be a slowly pulsating B-type (SPB:s) variable.

The TESS light curve of HD 36882 has at least 20 significant pulsation frequencies. I was not able to identify the likely variability type.

Acknowledgements

This research made use of the AAVSO VSX database and the SIMBAD and VIZIER databases, operated at CDS, Strasbourg, France and of NASA Astrophysics Data System Bibliographic Services. This paper includes data collected by the TESS mission, which are publicly available from the Mikulski Archive for Space Telescopes (MAST). This research made use of AAVSO's VStar software.

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Factors determining the accuracy of mid eclipse timing by polynomial fit – *Roy Axelsen*

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The accuracy of calculated times of mid eclipse from light curves of eclipsing binary systems is determined by the quality of the photometric data and the accuracy of the method used to analyse the light curve. This paper examines the latter, using light curves obtained by the author for three eclipses, one for CN Ind on the night of 25th August 2022, and two for CY Hyi on the nights of 6th and 11th December 2022.

Methods

Time series photometry was performed on digital images taken with a ZWO ASI1600MM CMOS camera through a 200mm f/2.8 Canon camera lens and either a red astrophotography filter (CN Ind) or a Johnson V filter (CY Hyi). Use of the red astrophotography filter (for CN Ind as reported here and for other stars not included in this paper) was an experiment, since the transformation coefficient Tr_{vr} is close to zero. Non-transformed R magnitudes are therefore almost entirely unaffected by the colour indices of the comparison stars, and minimally affected by differential extinction. Aperture photometry on images calibrated with dark and flat frames was performed using AstroimageJ.

For the submission of data to the Variable Stars South (VSS) database, times of mid eclipse were initially determined in VStar from polynomial fits, with the ‘best’ polynomial degree chosen using Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). The data range (i.e., the portion of the light curve) selected for these determinations was recorded. Once the best polynomial degree was decided in VStar, data from the same range was analysed in Peranso to find both the time of mid eclipse and the error of that determination. Note that VStar and Peranso compliment each other. VStar uses AIC and BIC to estimate the best polynomial degree to use but does not provide an error estimate for the time of mid eclipse. Peranso does not use AIC or BIC, but does give an estimate of the error of the time of mid eclipse.

For the study of factors involved in the accuracy of mid eclipse timing, multiple times of mid eclipse were determined using polynomial fits in Peranso, while varying both the range of data on which the times were determined and the polynomial degree, with the latter varying from 4 to 8. In practice, the initial data range for the polynomial fit was selected close to the time of mid eclipse. After applying 4th to 8th degree polynomial fits to this data range, the range was extended approximately symmetrically up the descending and ascending limbs of the eclipse light curve, and the polynomial fits re-applied. The process was repeated several times until the data range included most of the descending and ascending limbs of the eclipse light curve, or until poor data was encountered. In this manner, six data subsets were analysed for CN Ind and for the CY Hyi data from the 6th December 2022, and four data subsets were analysed for CY Hyi data from the 11th December 2022.

The data accumulated by these procedures was recorded in tabular and graphical form.

Results

The times of mid eclipse (HJD) submitted to the VSS database are shown in Table 1. The ranges of data selected for analysis from each of these eclipses covers most of the descending and ascending limbs of the light curve. This is representative of the author’s policy in selecting light curve segments for determination of times of mid eclipse: the selection covers half or more of the descending and ascending limbs of the eclipse, and will usually extend only minimally, if at all, into the upper parts of the light curve where the slope becomes convex up.

Star	Date	VSS TOM	VSS TOM Error	Polynomial Degree
CN Ind	8 Aug 2022	2459817.01997	0.0018	6
CY Hyi	6 Dec 2022	2459920.08682	0.0018	6
CY Hyi	11 Dec 2022	2459925.07989	0.0020	4

Table 1. Times of mid eclipse (TOM) determined by polynomial fit and submitted to the VSS database for the three variables included in this study. The degree of the polynomial selected for the determinations is listed on the last column to the right.

Data from the study of optimal data ranges and optimal polynomial degrees for determination of the times of mid eclipse are shown in Figures 1 to 3 and Tables 2 to 4. The figures are complex and require careful study, with the key to understanding being how the data points making up the light curve are divided into subsets. The legend for Figure 2 (left panel) describes this. Essentially, the first subset comprises data points just around mid eclipse, the second subset includes additional data points before and after this range, and so on until the last subset comprises most of the data points making up the descending and ascending limbs of the light curve.

For each of the subsets, Peranso is used to determine the time of mid eclipse by polynomial fit, with the polynomial degrees ranging from 4 to 8 in repeated estimates. These degrees were chosen from experience, being considered by the author to represent the range within which most ‘optimal’ polynomial fits fall.

Inspection of the results of polynomial fits in the right panels of Figures 1 to 3, shows a range of calculated times of mid eclipse for each of the light curve data subsets. It is proposed that those light curve subsets with the smallest ranges of values for the times of mid eclipse are likely to represent the most accurate values. These selected subsets and their descriptive statistics are listed in the tables (Tables 2, 3 and 4) beneath the corresponding charts.

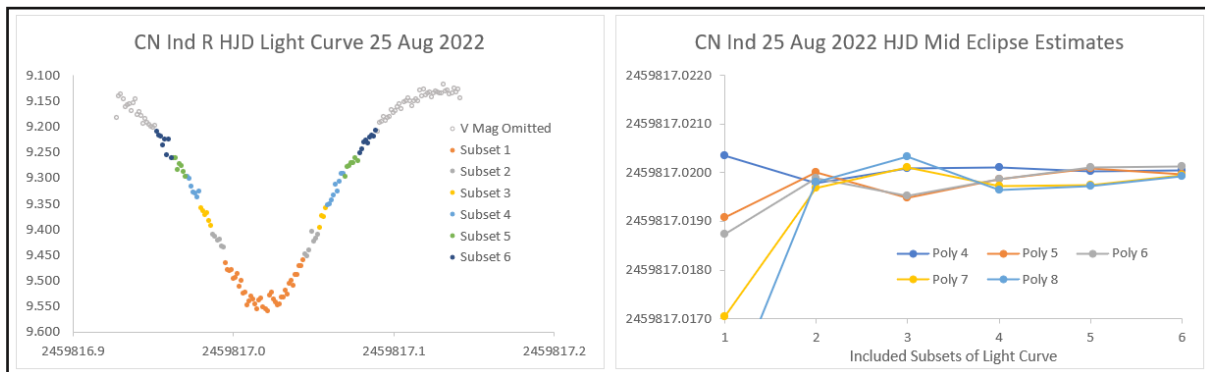


Figure 1. Light curve of CN Ind for 25 Aug 2022 (left panel), and calculated times of mid eclipse (right panel). Times of mid eclipse were determined for each of 6 subsets of the data, the ranges of which are shown by the coloured data points in the light curve. Subset 1 is represented by the orange/brown data points around the mid eclipse. Subsets 2 to 6 are defined by incrementally adding more data points, moving up both the descending and ascending limbs of the eclipse curve. For each subset, times of mid eclipse were determined from polynomial fits in Peranso, for 4th, 5th, 6th, 7th and 8th degree polynomials.

Subset	Ave TOM	SD TOM	Max TOM	Min TOM	Range TOM (d)	Range TOM (s)	Delta (d) with VSS TOM	Delta (s) with VSS TOM
2	2459817.01983	0.0001	2459817.02000	2459817.01969	0.00030	26.3	0.00014	12.0
4	2459817.01984	0.0002	2459817.02010	2459817.01965	0.00046	39.4	0.00013	11.3
5	2459817.01994	0.0002	2459817.02010	2459817.01973	0.00037	32.1	0.00003	2.6
6	2459817.02000	0.0001	2459817.02013	2459817.01994	0.00019	16.6	-0.00003	-2.8

Table 2. Tabulated results from the right panel of Figure 2, for the best subsets of data points, (i.e.), those subsets for which the ranges of calculated times of mid eclipse are the smallest. Column headings are explained as follows. Ave TOM (average time of mid eclipse) is the average of the TOMs from the five polynomial fits, with degrees 4 to 8. SD (standard deviation) TOM, Max (maximum) TOM, Min

(minimum) TOM, Range TOM (d, days) and Range TOM (s, seconds) are statistics calculated from the same five polynomial fits for each light curve subset. The last two columns show the differences in d (days) and s (seconds) between the official VSS TOM (from Table 1) and the Ave TOM.

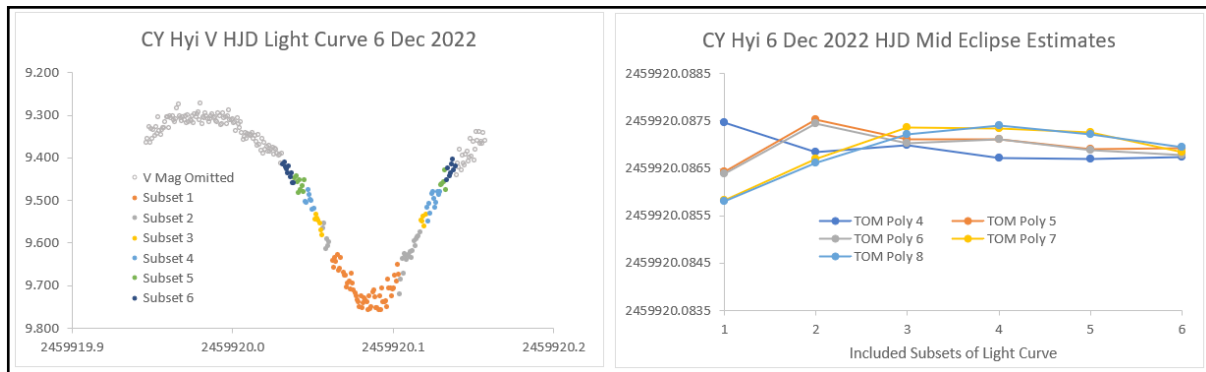


Figure 2. Light curve of CY Hyi for 6 Dec 2022 (left panel), and calculated times of mid eclipse (right panel).

Subset	Ave TOM	SD TOM	Max TOM	Min TOM	Range TOM (d)	Range TOM (s)	Delta (d) with VSS TOM	Delta (s) with VSS TOM
3	2459920.08715	0.00015	2459920.08737	2459920.08699	0.00038	32.7	-0.00033	-28.7
6	2459920.08685	0.00009	2459920.08694	2459920.08675	0.00019	16.5	-0.00003	-2.8

Table 3. Tabulated results from the right panel of Fig. 3, for the best subsets of data points. See the legend for Table 2 for explanation.

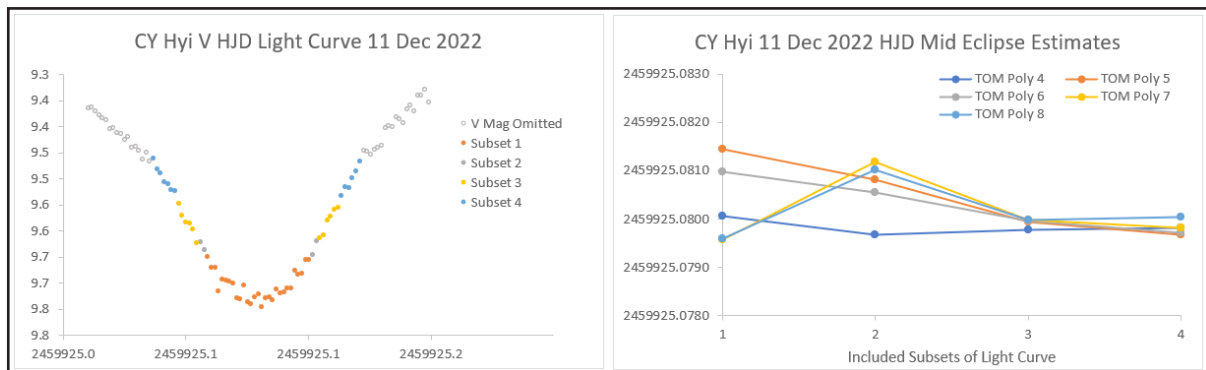


Figure 3. Light curve of CY Hyi for 11 Dec 2022 (left panel), and calculated times of mid eclipse (right panel). Note that only four subsets of data are defined for the light curve, because the precision of the measurements is poor in the upper part of the ascending limb of the light curve, caused by deteriorating atmospheric conditions.

Subset	Ave TOM	SD TOM	Max TOM	Min TOM	Range TOM (d)	Range TOM (s)	Delta (d) with VSS TOM	Delta (s) with VSS TOM
3	2459925.07993	0.0001	2459925.07998	2459925.07978	0.00021	18.0	-0.00004	-3.7
4	2459925.07981	0.0001	2459925.08004	2459925.07967	0.00037	31.7	0.00007	6.1

Table 4. Tabulated results from the right panel of Figure 3, for the best subsets of data points. See the legend for Table 2 for explanation.

Discussion

The times of mid eclipse submitted to the VSS database and the times of mid eclipse for several subsets of the light curve data and polynomial fits with 4 to 8 degrees were calculated completely independently. In particular, the selection of the data ranges defining the subsets of the light curves was made without reference to the data ranges actually used for the polynomial fits for the submissions to the VSS database.

The most striking outcome of the study is that the light curve subsets with the smallest ranges of times of mid eclipse from the several degrees of polynomial fits show the smallest differences between VSS TOM and Ave TOM (Tables 2, 3 and 4). However, the study involved data from only three eclipses. A larger sample may not necessarily yield such a consistent result. Nevertheless, the study provides confidence in the method usually employed by the author for calculating times of mid eclipse submitted to the VSS database.

A 12 bit camera was used in this study. The small well depth limits targets to brighter stars, and requires careful selection of gain and exposure settings to achieve optimal precision. Even so, it can be seen from the light curves in Figures 1 to 3 that the precision is less than that achievable with cameras with greater well depths. For these conditions the present study suggests that it is necessary to select a substantial range of data points around mid eclipse to achieve optimal accuracy in mid eclipse time determination. The results also clearly indicate that the range of data chosen for polynomial fitting is more important than the degree of the polynomial fit (see the third last column in Tables 2, 3 and 4).

The latter conclusion may also apply to light curves with better precision than that demonstrated herein. For example, a preliminary assessment was made of a light curve for QW Tel from TESS (Transiting Exoplanet Survey Satellite) data. When polynomial fits of 4th to 8th degree were applied to subsets of the light curve, the smallest range of calculated times of mid eclipse was found with the data subset limited to a small part of the light curve around mid eclipse. Further analyses would be needed to determine if that result applied also to other similar light curves.

Conclusion

A study of eclipsing binary light curves obtained by the author with a 12 bit CMOS camera suggests that the most important factor in determining the accuracy of the time of mid eclipse calculated by polynomial fit is the selection of the range of data points to which the polynomial function is fitted. For these light curves, obtained from EW eclipsing binary systems, the optimal data range extended from the upper part of the descending limb through the mid eclipse to the upper part of the ascending limb. The degree of the polynomial fit is not a significant contributor to the accuracy of the measurement. A preliminary study of a more precise light curve from TESS suggests that the optimal data range for polynomial fitting may be more closely confined to the region immediately around the time of mid eclipse. Further studies are needed on this point.

Chromospherical activity in the secondary component of BF Velorum — *David Moriarty*

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While checking spectra for BL Vel, I realised I had made misinterpreted the Na I D spectrum shown as Figure 3h in Newsletter NL 2022-3.

The lines marked with magenta arrows in Figure 3h are not those of a tertiary star with an unusually large velocity. Instead they are part of the blended sodium lines of all three components of BF Vel. The line centres labelled with the down arrows indicate emission in the sodium spectrum, most likely arising from the secondary component. As shown in Figure 4 in the 2022 July Newsletter, emission was displayed in the Balmer lines at phase 0 on two occasions. At that phase, the light of the secondary component would contribute a major portion of the flux of the sodium D doublet; the spectral type of the primary star is A5 V, so its sodium lines are weak in comparison with the Na I D lines of late G and K stars.

The corrected Fig. 3h is shown here (Fig.1).

Another small correction to the caption of Figure 3: The rest wavelengths marked with small upward arrows applies to Figure 3i, not 3h.

An updated model of BF Vel with Binary Maker 3 was reported in the VSS Newsletter 2022-4. The binary model at phase 0 is shown in Fig. 2. The secondary star has evolved and fills its inner critical equipotential surface. Its radius is about 90% of that of the primary component. With an effective temperature of 4880K, its spectral type would be about K1 IV.

The spectral type of the primary star is A5 V. The sodium lines of early and mid A stars are weak in comparison with those of late G and K stars. At phase 0, the light of the BF Vel K1 secondary component would contribute a major portion of the flux of the sodium D doublet. That would explain why the emission in the sodium D lines and Balmer lines are evident during the primary eclipses and not at other phases.

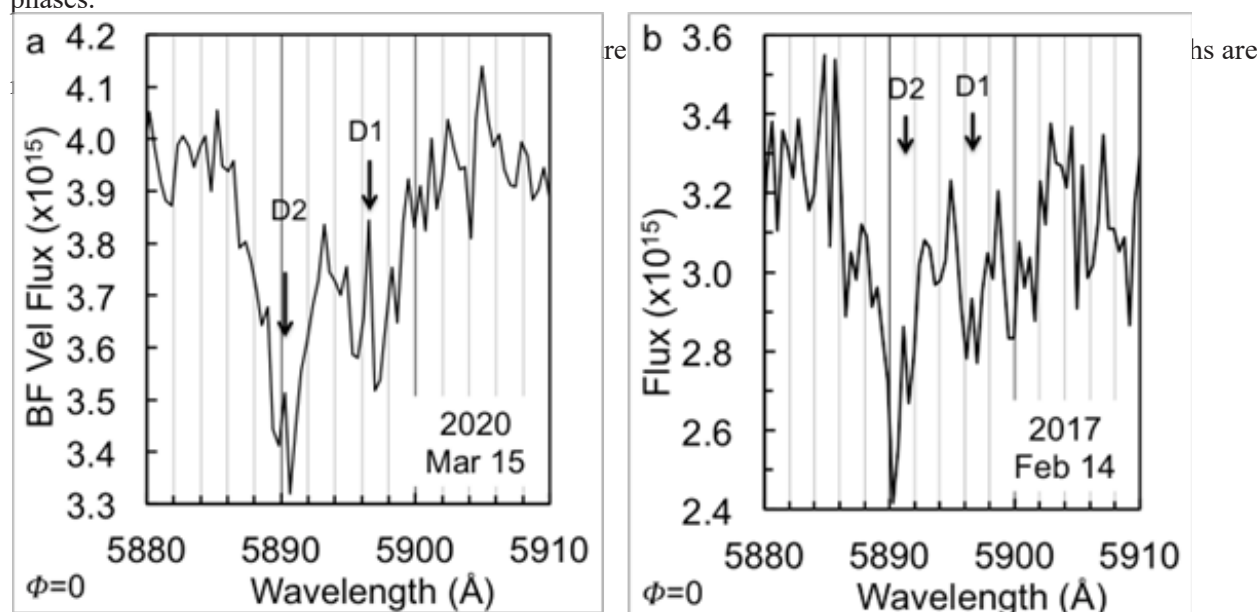


Figure 1. Spectra of the sodium D couplet of BF Vel during primary eclipses with emission in the line centres. (a) The correct version of Fig. 3h in nl_2022-3. Phase 0.003, exposure: 420 s. (b) Phase 0.992; exposure 90 s.

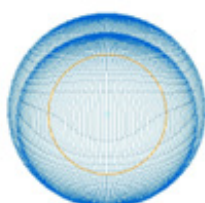


Figure 2. Binary model of BF Vel at phase 0. For comparison, the orange circle shows the Sun's size.

Obituary - Dr Robert (Bob) Nelson – *Robert Jenkins*

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The astronomy community have lost one of its stars, Dr Robert H Nelson – Bob to his friends. Bob died on 2nd November after a long battle with cancer. He is survived by his wife Lois and three adult children.

Bob was a prolific investigator of eclipsing binary systems for over 25 years, having published well over 100 papers on the subject (a large legacy of data is being written up or existing papers are being finalised by friends). He is probably best known for his database of “Eclipsing Binary O-C files” which is hosted on the AAVSO website and South West Research Institute plus software, especially Minima27, hosted at Variable Stars South and SWRI. Bob mentored many students and friends on astronomy.

Bob led a unique life, which reflected in his many interests. He taught physics at the College of New Caledonia in Prince George Canada for over 30 years. In 1974 he was one of the founders of the Caledonia Ramblers and enjoyed exploring the wonderful Canadian wilderness. In the 70’s he compiled a list of hikes that initially formed a still popular trail guide of the region. He also started the Prince George Astronomical Society, built two observatories and studied the skies with his backyard telescope as well as a remote telescope in Arizona. After retirement, his love of travel with Lois took them to many countries throughout five continents. He particularly loved Maui and enjoyed 400+ scuba dives over the years. Bob and Lois spent holiday time in Australia, staying with Tom and Lyn Richards.

An eternal optimist, Bob was indefatigable in his pursuit of the nature of eclipsing binary stars, both in their observation and their analyses. His enthusiasm for his art and science was infectious.

I got to know Bob when I found his O-C database on the AAVSO website. A question about some data several years ago made me realise that Bob had established the database and was managing/updating it primarily on his own. I offered to help and have spent many years collecting data and updating his workbooks. We never met in person but our regular Skype meetings (after we had sorted out our time differences) lasted for hours.

Efforts are underway within AAVSO to ensure that the legacy of his contributions remain available to the astronomy community. I will do the 2023 O-C workbook updates in January but then I will be putting out a call to establish a team to continue the work into the future, it is too big a job for one ordinary person.

We will all miss Bob Nelson.

Some websites of interest:

<https://www.aavso.org/bob-nelsons-o-c-files#Peg>

<https://www.variablestarssouth.org/resources/bob-nelsons-software-tools/software-by-bob-nelson>.

[Eclipsing Binary Observers Home Page \(swri.edu\)](http://swri.edu)

Phil Evans was a co-author on three exoplanet ArXiv papers and a contributor to an online VizieR catalogue.

Kokori, A., Tsiaras, Edwards, B. et al *ExoClock Project III: 450 new exoplanet ephemerides from ground and space observations.* arXiv:2209.09673

Abstract: The ExoClock project has been created with the aim of increasing the efficiency of the Ariel mission. It will achieve this by continuously monitoring and updating the ephemerides of Ariel candidates over an extended period, in order to produce a consistent catalogue of reliable and precise ephemerides. This work presents a homogenous catalogue of updated ephemerides for 450 planets, generated by the integration of ~18000 data points from multiple sources. These sources include observations from ground-based telescopes (ExoClock network and ETD), mid-time values from the literature and light-curves from space telescopes (Kepler/K2 and TESS). With all the above, we manage to collect observations for half of the post-discovery years (median), with data that have a median uncertainty less than one minute. In comparison with literature, the ephemerides generated by the project are more precise and less biased. More than 40% of the initial literature ephemerides had to be updated to reach the goals of the project, as they were either of low precision or drifting. Moreover, the integrated approach of the project enables both the monitoring of the majority of the Ariel candidates (95%), and also the identification of missing data. The dedicated ExoClock network effectively supports this task by contributing additional observations when a gap in the data is identified. These results highlight the need for continuous monitoring to increase the observing coverage of the candidate planets. Finally, the extended observing coverage of planets allows us to detect trends (TTVs - Transit Timing Variations) for a sample of 19 planets. All products, data, and codes used in this work are open and accessible to the wider scientific community.

Yee, S. Winn, J., Hartman, J. et al. *The TESS Grand Unified Hot Jupiter Survey. II. Twenty New Giant Planets.* arXiv:2210.15473

Abstract: NASA's Transiting Exoplanet Survey Satellite (TESS) mission promises to improve our understanding of hot Jupiters by providing an all-sky, magnitude-limited sample of transiting hot Jupiters suitable for population studies. Assembling such a sample requires confirming hundreds of planet candidates with additional follow-up observations. Here, we present twenty hot Jupiters that were detected using TESS data and confirmed to be planets through photometric, spectroscopic, and imaging observations coordinated by the TESS Follow-up Observing Program (TFOP). These twenty planets have orbital periods shorter than 7 days and orbit relatively bright FGK stars ($10.9 < G < 13.0$). Most of the planets are comparable in mass to Jupiter, although there are four planets with masses less than that of Saturn. TOI-3976 b, the longest period planet in our sample ($P=6.6$ days), may be on a moderately eccentric orbit ($e = 0.18 \pm 0.06$), while observations of the other targets are consistent with them being on circular orbits. We measured the projected stellar obliquity of TOI-1937A b, a hot Jupiter on a 22.4 hour orbit with the Rossiter-McLaughlin effect, finding the planet's orbit to be well-aligned with the stellar spin axis ($|\lambda| = 4.0 \pm 3.5^\circ$). We also investigated the possibility that TOI-1937 is a member of the NGC 2516 open cluster, but ultimately found the evidence for cluster membership to be ambiguous. These objects are part of a larger effort to build a complete sample of hot Jupiters to be used for future demographic and detailed characterization work.

Gan, Tianjun; Wang, Sharon X.; Wang, Songhu. et al. *Occurrence rate of hot Jupiters around early-type M dwarfs based on TESS data.*

Abstract: We present an estimate of the occurrence rate of hot Jupiters ($7 R_\oplus \leq R_p \leq 2 R_J$, $0.8 \leq P_b \leq 10$ days) around early-type M dwarfs based on stars observed by TESS during its primary mission. We adopt stellar parameters from the TESS Input Catalog, and construct a sample of 60,819 M dwarfs with $10.5 \leq T_{\text{mag}} \leq 13.5$, effective temperature $2900 \leq T_{\text{eff}} \leq 4000$ K and stellar mass $0.45 \leq M_* \leq 0.65 M_\odot$. We conduct

a uninformed transit search using a detection pipeline based on the box least square search and characterize the searching completeness through an injection and recovery experiment. We combine a series of vetting steps including light centroid measurement, odd/even and secondary eclipse analysis, rotation and transit period synchronization tests as well as inspecting the ground-based photometric, spectroscopic and imaging observations. Finally, we find a total of nine planet candidates, all of which are known TESS objects of interest. We obtain an occurrence rate of $0.27 \pm 0.09\%$ for hot Jupiters around early-type M dwarfs that satisfy our selection criteria. Compared with previous studies, the occurrence rate of hot Jupiters around early-type M dwarfs is smaller than all measurements for FGK stars, although they are consistent within $1-2\sigma$. Combining results from transit, radial velocity and microlensing surveys, we find that hot Jupiters around early-type M dwarfs possibly show a steeper decrease in occurrence rate per logarithmic semi-major axis bin ($dN/d\log 10a$) when compared with FGK stars.

Christian, S.; Vanderburg, A.; Becker, J. et al. *VizieR Online Data Catalog: 67 binary stars with exoplanet(s) from Gaia EDR3* (Christian+, 2022).

Abstract: Astronomers do not have a complete picture of the effects of wide-binary companions (semi-major axes greater than 100au) on the formation and evolution of exoplanets. We investigate these effects using new data from Gaia Early Data Release 3 and the Transiting Exoplanet Survey Satellite mission to characterize wide-binary systems with transiting exoplanets. We identify a sample of 67 systems of transiting exoplanet candidates (with well-determined, edge-on orbital inclinations) that reside in wide visual binary systems. We derive limits on orbital parameters for the wide-binary systems and measure the minimum difference in orbital inclination between the binary and planet orbits. We determine that there is statistically significant difference in the inclination distribution of wide-binary systems with transiting planets compared to a control sample, with the probability that the two distributions are the same being 0.0037. This implies that there is an overabundance of planets in binary systems whose orbits are aligned with those of the binary. The overabundance of aligned systems appears to primarily have semimajor axes less than 700 AU. We investigate some effects that could cause the alignment and conclude that a torque caused by a misaligned binary companion on the protoplanetary disk is the most promising explanation.

About

Variable Stars South is an international association of astronomers, mainly amateur, interested in re-searching the rich and under-explored myriad of southern variable stars.

Renamed from the Variable Star Section of the Royal Astronomical Society of New Zealand, it was founded in 1927 by the late Dr Frank Bateson, OBE, and became the recognised centre for Southern Hemisphere variable star research.

VSS covers many areas and techniques of variable star research, organised into projects such as Beginners' Visual Observations and Dual-Maxima Miras. The goal of each project is to obtain scientifically useful data and results. These may be published in recognised journals, or supplied to international specialist data collection organisations.

VSS is entirely an internet based organisation, working through our website <http://www.VariableStars-South.org> and its e-group <http://groups.google.com/group/vss-members>. It also encourages members to work in with major international organisations such as the British Astronomical Association, the Center for Backyard Astrophysics and the American Association for Variable Star Observers.

To find out more, please visit our website, where, incidentally, you will find PDF copies of all our newsletters. Our website has a great deal of information for VSS members, and for anyone interested in southern hemisphere variable star research. All VSS project information and data is kept here too.

Who's who

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Treasurer/Membership Bob Evans

Newsletter Editor Phil Evans

Webmaster David O'Driscoll

Visit our website to see a list of our area advisers, and to find out about our projects and how to contact their leaders

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After you've joined and received your membership certificate, you will be signed up to the VSS-members egroup (see above), and you will also receive a password to access the members' areas of our website.

Newsletter items

These are welcomed and should be sent to the Editor (phil@astrofizz.com). I'd prefer Microsoft Word (or compatible) files with graphics sent separately. Don't use elaborate formatting or fancy fonts and please do not send your contribution as a fully formatted PDF file.

Publication dates are January, April, July and October, nominally on the twentieth day of these months and the copy deadline is the thirteenth of the month though earlier would always be appreciated.

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