JAAVSO

Volume 36 Number 2 2008

The Journal of the American Association of Variable Star Observers

Research from the University of Toronto Mentorship Program

Bernadette Ho, Elena Favaro, and Jou Glasheen, co-authors of a study on pulsating red supergiant stars in this issue, with their poster at the University of Toronto Mentorship Program Research Fair.



Also in this issue...

- HD 208238 as a δ Scuti Variable Star
- The Light Curve of SU Carinae
- Recent Minima of Eclipsing Binary Stars
- Frequency Analysis of Long-term AAVSO Visual Observations



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JAAVSO

The Journal of The American Association of Variable Star Observers

Volume 36 Number 2 2008



49 Bay State Road Cambridge, MA 02138 U. S. A.

ISSN 0271-9053

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Journal of the American Association of Variable Star Observers Volume 36, Number 2, 2008

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Period Changes in Pulsating Red Supergiant Stars: A Science and Education Project

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Based on a paper presented at the 96th Fall Meeting of the AAVSO, Cambridge MA, November 3, 2007.

Received February 22, 2008; accepted March 26, 2008

Abstract We describe research done as part of the University of Toronto Mentorship Program, which enables outstanding senior high school students to work on research projects at the university. The students began with extensive background reading on variable stars, and became familiar with various forms of time-series analysis by applying them to a few red supergiant variables in the AAVSO International Database; we report on the results. They also prepared a useful manual for our publicly-available self-correlation analysis software. They undertook an intensive analysis of the period changes in BC Cyg, using the AAVSO and Turner data and the (O–C) method, in the hope that evolutionary period changes could be observed. The (O–C) diagram, however, is dominated by errors in determining the times of maximum, and by the effects of cycle-to-cycle period fluctuations. As a result, the (O–C) method is generally not effective for these stars. We also describe the Mentorship Program and its elements, and reflect on the students' experience.

1. Introduction

Red supergiants are the coolest, largest, most luminous stars, up to a thousand times larger in radius than the Sun. They are massive young stars in the final rapid stages of thermonuclear evolution. They undergo a complex variety of physical processes, including convection, pulsation, and extensive mass loss, which causes most of them to be shrouded in gas and dust. They are also all variable, though not strictly periodic, being classified as SRc if they are semiregular, and Lc if they are not. They vary typically on time scales of hundreds to thousands of days, and amplitudes up to a few magnitudes.

This project was inspired by two recent papers. Kiss *et al.* (2006) (hereinafter KSB) studied forty-eight SRc and Lc stars, using visual observations from the AAVSO International Database. The mean time-span of the data was sixty-one years. Most of the stars showed a period of several hundred days that could be ascribed to radial pulsation. Two or more periods were found in eighteen stars. In some cases, the second period could be an additional radial mode. In other cases, the second period was an order of magnitude longer than the radial period, and could be classified as a "long secondary period," similar to those that have been found in many pulsating red giants, and whose cause is unknown (Wood *et al.* 2004). From the Lorentzian shapes of the individual power spectra, KSB deduced the presence of period "noise," probably due to the interplay between pulsation and convection.

The second paper was by Turner *et al.* (2006) (hereinafter TRBP): they studied BC Cyg using both AAVSO visual data and data obtained from photographic plates in the collections of Harvard College Observatory and Sternberg Astronomical Institute. They concluded, among other things, that the pulsation period of BC Cyg had decreased from 699 to 687 days between 1900 and 2000. This period change, if real, might reflect the rapid evolution of this star.

The primary purpose of this paper was to study the period change in BC Cyg using the (O–C) method. A secondary purpose was to apply other forms of time-series analysis to this and other SRc and Lc stars. An equally important purpose was to provide an authentic research experience for three outstanding senior high school students.

According to the SIMBAD database, BC Cyg (M3.5Ia, HIP 100404, BD +37 3903) is an SRc variable with a photographic range of 11.3–13.8, $V \sim 10.0$, and a period of approximately 700 days; KSB report a period of 720 ± 40 days, and TRBP report a period decreasing from 699 to 687 days. Josselin and Plez (2007) derive the following physical properties for this star: M/M = 20, T_{eff} = 3570K, log R/R = 3.09, M_{bol} = -8.62.

2. The University of Toronto Mentorship Program

Authors EF, JG, and BH were participants in the University of Toronto Mentorship Program (UTMP). This program enables outstanding senior high school students to work on research projects at the University. JRP's goal is to provide the students with a reasonably structured research experience that, among other things, enables them to complete a small, self-contained research project that will result in a conference presentation and/or publication. Two other examples of recent UTMP projects are Percy *et al.* (2006), and Percy and Palaniappan (2006). A UTMP co-author of the former paper, Wojciech

Gryc, was a 2008 winner of a Rhodes Scholarship. The UTMP is structured as follows. In May, faculty members submit project descriptions. In August, mentorship program packages, with project descriptions, are sent to all high schools in the Greater Toronto Area. In September, students submit applications: resumé, transcript, references, and statement of interest in one or two projects. In October, faculty select and interview a short list of students; JRP chooses one to three students each year. In November, students begin their project, starting with reading, introduction to data and software-light curves, Fourier, least-squares, self-correlation, (O-C) analysis, and random cycle-to-cycle period fluctuations. They meet with their supervisor every week or two, to discuss both their project and astronomy in general. Often, they attend other astronomical events, such as lectures and star parties. In May, there is a UTMP reception and "research fair," featuring poster presentations on projects from across the University-mostly from the Faculty of Arts and Science. Figure 1 shows co-authors EF, JG, and BH at the research fair. By June, the projects are completed, and prepared for presentation and publication. Often, the students are employed in the summer for a few tens of hours to complete or extend their projects. The UTMP gives students a head start in their research career, which can be very helpful when they undertake their undergraduate studies.

3. Sources of data

Measurements of the SRc and Lc stars came from two sources: (i) Visual measurements from the AAVSO International Database, spanning up to a century; (ii) For BC Cyg, photographic measurements made by DGT from the Harvard Observatory plate collection and by TRBP from the plate collection of the Sternberg Astronomical Institute, spanning just over a century. See TRBP for a discussion of the nature and comparability of these two datasets. As an initial activity, EF, JG, and BH plotted sample light curves, and estimated times of maximum and minimum for several of the larger-amplitude variables.

4. Redetermination of periods by self-correlation

Self-correlation is a simple method of time-series analysis that determines the characteristic time scale and amplitude of the variability, averaged over the dataset. For a discussion of its nature, strengths, and weaknesses, see Percy and Mohammed 2004 and references therein. Our self-correlation software is freely available at:

http://www.astro.utoronto.ca/~percy/index.html

and a new manual for its use, written by co-authors EF, JG, and BH, is available at:

http://www.astro.utoronto.ca/~percy/manual.pdf

As a learning exercise, we began by generating self-correlation diagrams for several stars in KSB's list. The results are as follows:

T Cet showed a time scale of 163 days; the estimated uncertainty is about 3 days. KSB obtained periods of 161 ± 3 and 298 ± 3 days. Co-author DGT separately obtained a period of 288 days by Fourier analysis. The literature periods, as quoted by KSB, are 110, 159, and/or 280 days.

RW Cyg showed a time scale of about 500 days, in agreement with the result of KSB— 580 ± 80 days—and the literature periods of 550 and 586 days (KSB).

BC Cyg's self-correlation diagram for the AAVSO data is quite regular, and gives a period of about 700 days, as it does for the combined AAVSO-Turner data. The self-correlation diagram for the Turner data alone is somewhat more scattered.

BU Gem showed a time scale of 2500 days, in good agreement with KSB's result of 2450 ± 750 days. The literature periods are 272 and 1200 days (KSB). There is *weak* evidence for a time scale of 150 days in our self-correlation diagram, but the corresponding amplitude is only 0.01 magnitude.

For XX Per, KSB did not determine the short period. The literature periods are 415 and 4100 days (KSB). Self-correlation analysis gives a slightly irregular period of about 300–350 days (Figure 2).

AH Sco showed a time scale of 380-400 days, approximately half of the period (738 ± 78 days) found by KSB. The self-correlation diagram is complex. The light curve shows evidence of both time scales, at different epochs. Co-author DGT separately obtained a period of 769 days by Fourier analysis. The literature period is 714 days (KSB).

VX Sgr showed a time scale of 750 days, in good agreement with KSB's period of 754 days, though we found possible evidence of weak interference from a time scale of about 250 days. Co-author DGT separately obtained a period of 757 days by Fourier analysis. The literature period is 732 days (KSB).

For CE Tau, KSB did not determine a short period. The literature period is 140–165 days (KSB). Self-correlation analysis gives a well-determined period of 350–375 days (Figure 3). This is suspiciously close to one year, and the amplitude is only 0.02 magnitude, which suggests that the period may be spurious, and due to the well-known "angle effect" in visual photometry. This is caused by the changing relative position of the variable and the comparison stars during the year. CE Tau and a few other stars show small peaks in KSB's Fourier spectra at a period of 365 days.

W Tri showed a time scale of about 107 days, in agreement with KSB's result of 107 ± 6 days. We also found a more complex time scale of about 600 days, in agreement with the period of 590 ± 170 days, found by KSB. Co-author DGT separately obtained a period of 592 days by Fourier analysis.

5. Light curves and times of maximum

The light curves of SRc variables are not regular, as can be seen from those presented by KSB, or from generating light curves using the Light Curve Generator function on the AAVSO website. Figure 4 shows a partial light curve of VX Sgr, for example. It includes one of several epochs at which the amplitude became very small. At these epochs, it is almost impossible to estimate times of maximum or minimum. Omitting these intervals, however, may bias the application of the (O–C) method or of the Eddington-Plakidis method, discussed below. Variable amplitudes *could* be produced by interference between two close periods, in which case there is a characteristic variation in (O–C) across the epoch of minimum amplitude. On the other hand, if the variation in amplitude is caused by an actual variation in pulsation energy, there will be no resulting variation in (O–C).

For VX Sgr, the observations are dense, and the amplitude is up to five magnitudes; it was the largest-amplitude variable in our study. For BC Cyg, the observations are much less dense, and the amplitude is typically one to two magnitudes. So it is even more difficult to determine times of maximum or minimum, especially by eye.

Times of maximum were determined using three methods: eye estimates, the epoch calculator within PERIOD04 (Lenz and Breger 2005), and least-squares fitting of cycles within PERIOD04; the last two are closely related, so we lump them together.

6. Period changes in BC Cyg using the (O-C) method

Figure 5 shows the (O–C) diagram for BC Cyg, using the TRBP data, times of maxima determined by eye, and a period of 693 days. This is probably the most reliable (O–C) diagram, in the sense that it contains fewer gaps, in which the cycle count is uncertain. It is dominated by a cyclic pattern, though the <u(x)> diagram suggests that this pattern is *not* due to random cycle-to-cycle period fluctuations.

Table 1 lists the results of the (O–C) analysis for BC Cyg, using the two datasets, two methods of determining times of maximum, and two possible values of the period. The last column lists the curvature—the coefficient of N^2 in the best-fit parabola, along with its standard error. In no case is the curvature statistically significant (at the 3σ level).

If the period decrease found by TRBP is correct, it would imply a coefficient of -0.114, which is within the error of the determinations in Table 1, and specifically of the (O–C) diagram in Figure 5, namely -0.163 ± 0.259 .

We also plotted (O–C) diagrams for RW Cyg, XX Per, VX Sgr, and CE Tau, for which we had AAVSO data only, In each case, the curvature of the best-fit parabola was considerably smaller than its standard error, so we have no positive results to report.

7. Random cycle-to-cycle period fluctuations

These were determined from the times of maximum or minimum using the formalism of Eddington and Plakidis (1929), using an algorithm written by Deepak Chandan (2007) in EXCEL. This determines the average cycle-to-cycle period fluctuation ε , and the average observational error α in determining the times of maximum or minimum. The diagnostic equation is:

$$\langle \mathbf{u}(\mathbf{x}) \rangle^2 = 2\alpha^2 + \mathbf{x}\varepsilon^2 \tag{1}$$

where u(x) is the average difference in (O–C)s which are x cycles apart.

As a test of his program, Chandan generated a $\langle u(x) \rangle$ diagram for VX Sgr, using only well-determined times of maximum; he found an average fluctuation per 743-day cycle of 55.8 days, or about 7 percent. The average observational error in determining the time of maximum or minimum is 120 days, as determined from the intercept, or 78 days as determined from the value of u(1). (We have found that, especially in cases in which the $\langle u(x) \rangle$ diagram is not exactly linear, u(1) is a better estimation of α .)

For T Cet, which is a luminosity-class II star, not a supergiant, he found the slope of the line in the Eddington-Plakidis algorithm to be negative, but not significantly different from zero. When one low-weight u(x) value was omitted, the slope changed noticeably, but was still not significantly different from zero. There are thus no significant random cycle-to-cycle period fluctuations.

The $\langle u(x) \rangle$ diagram for BC Cyg, using the same data as shown in Figure 5, is shown in Figure 6. The points clearly do not follow a straight line. This is not surprising, given the quasi-cyclic nature of Figure 5. The slope of the best-fit straight line is 142 ± 327 , which is not significantly different from zero. The intercept is 14800 ± 3542 but, since a straight line is not a good fit to the data, the intercept is better estimated from u(1). The value of α is 70 ± 20 days, or about 0.1 period.

8. Discussion and conclusions

The interpretation of the (O–C) diagram of pulsating red supergiants appears to depend, to a large extent, on how the times of maximum are measured. This is because most of the visual light curves are not very dense, and the amplitudes are not large—a magnitude or two. We have tried measuring the times by eye, and by fitting techniques such as the least-squares function in PERIOD04. They do not produce identical results. Normally, the "statistical" method will be superior but, in applications such as this one, the human eye/brain system can be a very sophisticated and effective computer. The large values of α found in the <u(x)> analysis are a reflection of this problem. An inherent problem in working with sparse visual data is that different measurements may come from different observers whose eyes have different sensitivities, so there will be both random and systematic errors, whether the times of maximum are measured by eye or by computer. The u(x) analyses for T Cet, BC Cyg, and VX Sgr suggest that the average observational error α in measuring the time of maximum or minimum is about 0.1 period, or more.

Therefore it is not possible to measure evolutionary period changes in these stars using the (O–C) method, because the curvature of the (O–C) diagram is not statistically significant. Only with one data set—that of the AAVSO—and with one method of measurement of the times of maxima—by eye—do we find a significant curvature for BC Cyg, but not quite at the 3σ level. The other results in Table 1 do not support this result, including those using the more extensive TRBP data. So it is still possible that BC Cygni has an evolutionary decrease in period; as noted above, the period decrease proposed by TRBP corresponds to a curvature that is within the errors of our determination.

We conclude that the approach of KSB—that is to use the (Lorentzian) profile of the peaks in the power spectrum as an indication of the "scatter" in the period—is a better approach than trying to estimate numerous times of maximum in a sparse, semiregular, low-amplitude light curve, and using the (O-C) method. Note that the *width* of the peaks in the power spectrum provides information about the *uncertainty* in the mean period, as noted by Kwee, van Woerden, Fernie and others many years ago.

The (O–C) diagrams are dominated by cyclic variations, but it is not clear whether these are the same kind of *random* cycle-to-cycle period fluctuations that dominate the (O–C) diagrams of pulsating red giants (Percy and Colivas (1999) and references therein). For BC Cyg, the diagnostic (Figure 6) does not support the period-fluctuation hypothesis, although, for VX Sgr (not shown), it does.

What is the nature of the variability and its complexity? KSB noted that convection could play an important role in producing the variability, and modifying—and perhaps even exciting—the pulsation. Gray (2008) has carried out a detailed long-term spectroscopic study of Betelgeuse (M2 Iab), and compared the spectroscopic variations with AAVSO visual photometry. He concludes that the photometric variability is largely caused by enormous convection cells, with turnover times of about 400 days, comparable to the radial pulsation time scales. KSB estimated the mode lifetimes for Betelgeuse to be about three cycles, after which another convection cell emerges, and chaotic behavior is created in the parameters of the variability. The stochastic nature of the convection, and its driving effect on the pulsation, produces the wandering period, variable amplitude, and variable phase that we observe (Gray 2008).

If the surface of the star is dominated by one or two giant convection cells, and if their lifetime is sometimes comparable with the star's rotation period, then we might expect to see some variability on a rotational time scale. This may cause some of the long-term variability in both the brightness and the phase (as measured by (O–C)) in some of these stars.

Self-correlation analysis is a useful adjunct to Fourier analysis for determining the time scales of these stars, as it has been for other types of semiregular variables. For at least two stars in our dataset, it provides new information about the period of the star.

AAVSO visual observations are essential for understanding these stars. The behavior of these stars is so slow and complex, and there are so many types of long-term variability, that the visual observations provide the only hope for further understanding. The longer the dataset, the better our chance of understanding will be.

AAVSO and other variable star data, and the many available user-friendly data analysis programs, provide a wide range of useful educational resources that enable students to "learn science by doing science" with real data. This is certainly true for both undergraduate students, and for the students in the UTMP. They enrich their education, contribute to our understanding of stars and their evolution, and provide feedback and satisfaction for the hundreds of observers who have contributed to the AAVSO International Database.

9. Acknowledgements

We thank Deepak Chandan, Rohan Palaniappan, and Rajiv Seneviratne for their assistance with various aspects of this project; the organizers of the University of Toronto Mentorship Program (especially Farheen Hasan); the Natural Sciences and Engineering Research Council of Canada, and the Ontario Work-Study Program for research support; and the AAVSO observers and headquarters staff, without whose efforts this project would not be possible. This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France.

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| Data | Max/Min Determined By | Period (d) | Quadratic Coefficient |
|-------|--------------------------|------------|-----------------------|
| AAVSO | Period04 | 693 | -2.46 ± 1.38 |
| AAVSO | eye | 693 | -2.52 ± 0.842 |
| AAVSO | eye | 720 | 0.738 ± 1.35 |
| TRBP | Period04 | 693 | 0.125 ± 0.388 |
| TRBP | eye | 693 | 0.016 ± 0.184 |
| TRBP | eye | 720 | 0.230 ± 0.399 |

Table 1. (O-C) Analyses of BC Cyg.



Figure 1. Co-authors Bernadette Ho, Elena Favaro, and Jou Glasheen, with their poster at the University of Toronto Mentorship Program Research Fair. The white Christmas lights add a festive and somewhat astronomical touch.



Figure 2. The self-correlation diagram (Δ mag versus Δ time) for XX Per. The minima are very shallow, corresponding to amplitudes less than 0.02, and do not repeat in any coherent pattern. The literature period is 415 days, and the self-correlation diagram is not inconsistent with this.



Figure 3. The self-correlation diagram (Δ mag versus Δ time) for CE Tau. There are repeating minima at multiples of 375 days, indicating that this is the dominant time scale in the data. The literature period is 140–165 days.



Figure 4. A 15000-day light curve of VX Sgr, based on visual observations from the AAVSO International Database. Note the epoch at which the amplitude becomes small, and the times of maximum and minimum become nearly impossible to determine.



Figure 5. The (O–C) diagram for BC Cyg, using times of maximum determined by eye from the data of Turner *et al.* (2006), and using a period of 693 days. The line shows the best-fit parabola; the curvature, 0.0160 ± 0.184 , is not significantly different from zero.



Figure 6. The $\langle u(x) \rangle^2$ (Eddington and Plakidis 1929) diagram for BC Cyg, based on the (O–C) data shown in Figure 5. The line is the best-fit straight line, but it does not fit the data very well. The nominal slope corresponds to an average cycle-to-cycle fluctuation of 12 days but, as noted in the text, the slope of the line is not significantly different from zero.

HD 208238 as a δ Scuti Variable Star

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Received September 5, 2008; revised October 5, 2008; accepted October 10, 2008

Abstract We present observations that show HD 208238 to be a variable star with a period of 0.048622 day and with a range of 0.021 and 0.018 magnitude in the *V* and *R* filters, respectively. Its spectral type is determined to be A4V or A5V. We conclude that this star is a hot δ Scuti variable star.

1. Introduction

HD 208238 is a ninth magnitude star (R.A. $21^{h} 54^{m} 33.5^{s}$, Dec. $+14^{\circ} 32'$ 05.28" (2000)). Its HD catalogue spectral type is A3. The star is located just 2.7 arc minutes from the eclipsing binary DF Peg. While observing DF Peg, we discovered that HD 208238 is likely a δ Scuti variable star. δ Scuti variable stars are generally low amplitude variables, with spectral types usually between A5 and F2, and short periods (0.02 to 0.3 day), although most are multi-periodic. Variability is attributed to radial and non-radial pulsations. They are located at the intersection of the Cepheid instability strip and the main sequence on the HR diagram (see Percy 2007; Templeton 2004 for overviews).

2. Observations

HD 208238 was observed with a 0.4-meter telescope and an SBIG ST-10 CCD camera of the Ball State University observatory. The f/6 focal ratio gave a scale of 0.58 arc second per pixel. The exposures alternated between the V and R filters, with typical exposure times of 50 and 35 seconds, respectively. The CCD images were collected in an autonomous mode where the telescope and camera were controlled by CCDAUTOPILOT (Smith 2008). The observations are summarized in Table 1. They were made with Johnson-Cousins V and R filters. IRAF (Tody 1993) was used to subtract the bias and dark current, and to flat-field correct each image. Differential aperture photometry was done with the software package AIP4WIN (Berry and Burnell 2006). Information about the comparison and check stars can be found in Table 2. There are a total of 498 V and 495 R measurements. Photometric errors of each measurement were

determined by a signal-to-noise calculation involving camera read noise, camera gain, dark current, and the sky background. The error for each delta magnitude was found by adding the individual errors for the variable and comparison star in quadrature. The typical error of a differential measurement ranged between 0.002 and 0.004 magnitude.

3. Light Curves

Figure 1 shows the instrumental differential V and R magnitudes versus time for the night of August 8, 2008 (UT). There is a max-to-min variation of about 0.021 and 0.018 magnitude in V and R, respectively. A Lomb-Scargle power spectrum (Lomb 1976; Scargle 1982) of the V data produced with the PERANSO software package (Vanmunster 2007) is shown in Figure 2. There is a single strong period with the usual 24-hour aliases. This period is the same for both filters, 0.048622 \pm 0.000026 day. Figure 3 shows the V data phased on this period. Figure 4 shows the period search after pre-whitening with this period. No significant residual periods are seen. Also, period searching a single night (August 8) produced the same period (0.0486d) without the aliases.

4. Spectral Classification and Color

HD 208238 was classified on an objective-prism plate taken with the 60-cm Burrell Schmidt at Kitt Peak National Observatory (KPNO). The exposure was 20 minutes on Kodak IIa-O using a 10-degree prism, yielding a dispersion of about 110Å/mm at H γ ; the spectra are widened 0.8 mm. Matching directly against exposures of MK standards of similar photographic density, the star appears to be of type A4/5V (i.e., type A4 or A5) with no peculiarities evident at ~2Å resolution. The luminosity class was estimated by comparison of line ratios in giants and dwarf standard stars. Using the parallax from the Hipparcos catalog, an assumed interstellar extinction of 1 mag / kpc and R = 3, an intrinsic (*B*–*V*) was estimated to be 0.15–0.18. This is consistent with the value of 0.15 for an A5V star (Lang 1992). Given the uncertainty in the extinction assumptions, a spectral type of A4V is not excluded by these estimates.

5. Conclusions

HD 208238 is a δ Scuti variable star. This classification is consistent with the amplitude and period of the light variations and its spectral type. This star appears to be one of the hotter members of the δ Scuti class of variable stars.

It is somewhat ironic that Soydugan *et al.* (2006) predicted that one component of the eclipsing binary DF Peg was likely to be a δ Scuti star. We found no evidence of DF Peg displaying this behavior, but a star just 2.7 arc minutes away, HD 208238, does.

6. Acknowledgment

We would like to thank Arne Henden and an anonymous referee for their helpful comments. This work was funded by the Indiana Space Grant Consortium (NASA).

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| UT Date | HJD Range | Mean Differe | ential Error |
|----------------|------------------|--------------|--------------|
| | | ΔV | ΔR |
| 2008 July 24 | 2454671.69908731 | 0.00245 | 0.00234 |
| 2008 August 3 | 2454681.63697646 | 0.00285 | 0.00302 |
| 2008 August 8 | 2454686.63359142 | 0.00327 | 0.00345 |
| 2008 August 11 | 2454689.62438629 | 0.00393 | 0.00407 |
| 2008 August 12 | 2454690.61878043 | 0.00370 | 0.00377 |

Table 1. HD 208238 observations summary.

Table 2. Comparison and check stars.

| | Designation | R.A. (2000) | Dec. (2000) | V | R |
|-------|-----------------|---|---------------------------------------|----------|------------|
| | | | | (NOMAD)* | * (NOMAD)* |
| Comp | BD+13 4805 | 21 ^h 54 ^m 40.1 ^s | +14° 37' 06.3" | 10.90 | 10.61 |
| Спеск | 1YC 1134-08/6-1 | 21" 54" 57.7" | $+14^{\circ} 2/^{\circ} 3/.8^{\circ}$ | 11.// | 11.30 |

*Naval Observatory Merged Astrometric Dataset (NOMAD, Zacharias, et al. 2004).



Figure 1a. ΔR magnitudes of HD 208238 on the night of 2008 August 8 (UT).



Figure 1b. ΔV magnitudes of HD 208238 on the night of 2008 August 8 (UT).



Figure 2. The power spectrum analysis of the differential *V* magnitudes of HD 208238.



Figure 3. The differential *V* magnitudes of HD 208238 phased on the determined period.



Figure 4. Results of period-searching the *V* data after removing the 0.048622-day period.

The Light Curve of SU Carinae

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Received February 15, 2008; revised February 18, 2008; accepted February 18, 2008

Abstract Pitfalls for observers are highlighted through examination of the light curve of SU Car. For many years this Mira variable has been misidentified during certain parts of its light curve. The reasons are explored and valid observations discerned. A reviewed light curve is presented, to which is added data (containing no misidentifications) from 1962 to 1972. This last is presented as part of a longer-term, if fragmentary, light curve, probably for the first time. Finally, a new "g" scale chart is offered to aid better quality observations in the future.

1. Introduction

Observers experienced and otherwise, including the *All Sky Automatic Survey* (ASAS, Pojmański 2002), have had trouble identifying the Mira variable SU Car when faint (<12th magnitude). Figure 1 shows the last twelve years of observations of SU Car from the combined data bases of the AAVSO, the ASAS, and the Variable Star Section of the Royal Astronomical Society of New Zealand (VSS RASNZ). The confusion in the light curve appears in all these data sets, and is shown by the plateau of "noise" between 12th and 13th magnitude interrupting the rise and fall a Mira variable is expected to show.

In passing it is worth noting that the SIMBAD online database states correctly the range of SU Car as 10–17.5p but incorrectly states the period as 230.9 days (citing Kukarkin *et al.* 1971). The online version of the *General Catalogue of Variable Stars* (GCVS, Samus 2004), however, correctly lists the period as 575.6 days, citing Bateson and Menzies (1975).

2. The observations

2.1. Background

SU Car (= HD 88918 R.A. (2000) $10^{h} 13^{m} 30.42^{s}$, Dec. $-60^{\circ} 53' 09.5''$) was discovered by A. Cannon (Cannon *et al.* 1909); her examination of fifty photographs showing a long period variable with a period thought to be 231 days. Regular observation of the star did not commence until 1961, when the VSS RASNZ began a study lasting until 1972, and published in Bateson and

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Menzies (1975). They found the period to be 575.6 days with a visual maximum of between 8.5 to 10.9v. There was no attempt to observe the object past 12th magnitude or so.

2.2. 1962-1972

A chart was made for the RASNZ study by plotting stars from the *Cape Photographic Durchmusterung* (CPD, Astron. Data Center 1993) catalogue down to about 11.5B, and then sketching stars at the telescope down to about 13.0v. The sketch was confined to sequence stars, only. Field stars not relevant were ignored. The completed chart was eventually published as chart 284 (Bateson *et al.* 1971). The sequence stars used were labeled with letters, as reliable *V* magnitudes were not yet known. Menzies later determined the *V* and B-V values for the lettered stars on chart 284 in order to write the Bateson and Menzies (1975) paper.

The observations of SU Car from 1962 to 1972 were not in the RASNZ (or AAVSO) database at the time of writing. They were originally published in the form of seven short handwritten graphic fragments. The original observers' notes being unavailable, these graphs were enlarged and overlaid with a grid, and the estimates then entered into PERANSO light curve software (Vanmunster 2005) for use here. The obvious uncertainty with this method does not matter much with a star of this nature. These data constitute the first section of the light curve in Figure 2.

2.3. 1977-2008

The next data that appear are from 1977 onwards, and are contained in the databases of the RASNZ, the AAVSO (which is almost identical), and later, the ASAS (Pojmański 2002). All of these data are problematic. Concerning the visual observations, it appears that the causes of the errors seen in Figure 1 have been attempts to make estimates fainter than chart 284 and its 1995 replacement chart 1105 (Bateson and Morel 1995), which was designed to be used down to, for example, 12.9v. The chart was designed to do what it did: correctly determine the period of the Mira variable. The chart was never designed to be used as deeply as has been attempted, and it causes misidentifications when used near the limit of the chart and beyond. The complete sequence of RASNZ charts 284 and 1105 is shown in Table 1. The cause of the ASAS misidentifications is not known. However, with a pixel size of 15" in such a crowded field, proximate objects could well be responsible.

2.4. Two skilled observers

Examination of the post-1977 data separated into individual observers shows only two people who appear to have avoided problems: Peter Williams and Rod Stubbings. First, both have been careful to identify the variable when faint. Stubbings then used comparison stars in nearby fields, of which there are plenty in this part of the sky, to extend the sequence (Stubbings 2008). Williams used another way. He "eyeballed" an appropriate star, in this case one of \sim 13.5v, and also used the limiting magnitude on a given night of his 30-cm Newtonian as a fainter-still "comparison star" (Williams 2008).

Both are thoroughly experienced and skilled observers who correctly identified the variable over a period of years and their estimates are to be taken seriously. The worst one should do is simply to assign them greater error bars than usual.

2.5. Reviewing the observations

It is worth subjecting all available data to an editing process to see what remains. First, all of the Bateson and Menzies (1975) data can remain untouched, as can those of Williams and Stubbings. Of the rest, including the ASAS data, all estimates less than 12.0v are removed, including those of one of us (A.P.). This cutoff is chosen to be well out of the way of the above mentioned problems yet retain information about the period and maxima.

3. The reviewed light curve

The observations remaining after the above process comprise Figure 2. Note that virtually no observations from the period 1977–1992 remain after this treatment. For comparison, both the edited Figure 2 data and the entire unedited observation set (not shown here) are subjected to period analysis and the resulting phase plots shown. The periodograms of the two sets are identical, one of which appears as Figure 3, and show a period 575.3740 days. This is in fine agreement with the 575.6 days found by Bateson and Menzies (1975) and in the online GCVS, if not the SIMBAD database. The phase diagram of the unedited data set is shown in Figure 4(a) and that of the edited set in Figure 4(b).

4. Conclusion: a "g" scale chart

By way of conclusion, a new "g" scale chart is presented as Figure 5 to help with the future observation of SU Car, and an extended provisional sequence is given in Table 2. It is hoped that when problems like this are found and discussed there is less chance of them happening in the future—with any variable star.

5. Acknowledgements

Thanks go to Bob Evans and Ranald McIntosh of the RASNZ, Peter Williams, Rod Stubbings, and all of the observers from the AAVSO and the RASNZ who have observed this star. This research has made use of the SIMBAD database, operated at Centre de Données astronomiques de Strasbourg, Strasbourg, France.

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| Chart Nr. | mag. | R.A. | (2000) | De | ec. | V | B–V | S | HD/DM |
|-----------|------|-------|-----------|----|------|-------|-------|-----|-------------|
| 284/1105 | | h m | s ° | ' | " | | | | |
| а | 82 | 10 11 | 32.54 -61 | 14 | 23.3 | 8.12 | +0.56 | HIP | 88663 |
| с | 87 | 10 13 | 2.53 -61 | 10 | 44.9 | 8.49 | -0.11 | T2 | 88844 |
| b | 85 | 10 15 | 30.43 -60 | 44 | 16.5 | 8.51 | +0.55 | HIP | 89187 |
| d | 90 | 10 10 | 47.66 -60 | 56 | 34.8 | 8.96 | -0.05 | T2 | 88543 |
| e | 91 | 10 14 | 53.02 -60 | 44 | 30.8 | 9.14 | +0.08 | T2 | 89096 |
| f | 93 | 10 11 | 42.64 -60 | 50 | 5.0 | 9.18 | -0.06 | T2 | 88674 |
| g | 96 | 10 16 | 1.67 -60 | 42 | 47.7 | 9.41 | +0.25 | T2 | 89218 |
| 1 | 95 | 10 13 | 48.41 -60 | 52 | 46.1 | 9.52 | +1.10 | 23 | 305018 |
| h | 99 | 10 14 | 21.24 -61 | 2 | 26.2 | 9.79 | +0.01 | T2 | 89017 |
| m | 99 | 10 13 | 41.33 -60 | 51 | 31.3 | 9.85 | +1.02 | 23 | 305017 |
| q | 109 | 10 13 | 51.88 -60 | 52 | 1.7 | 10.87 | +1.25 | 23 | |
| 0 | 109 | 10 12 | 59.28 -60 | 54 | 6.4 | 10.93 | +0.69 | 26 | |
| k | 111 | 10 13 | 3.17 -60 | 58 | 5.4 | 11.06 | +0.10 | 26 | CPD-60 1764 |
| р | 112 | 10 13 | 44.33 -60 | 52 | 13.8 | 11.19 | +1.67 | 23 | |
| n | 113 | 10 12 | 58.06 -60 | 55 | 21.8 | 11.32 | +0.01 | 26 | CPD-60 1762 |
| S | 119 | 10 13 | 19.71 -60 | 49 | 41.0 | 11.87 | +0.81 | 26 | |
| t | 120 | 10 13 | 20.90 -60 | 48 | 35.6 | 12.01 | +1.71 | 23 | |
| r | 129 | 10 13 | 26.40 -60 | 51 | 1.6 | 12.89 | +0.24 | 23 | |
| ASAS | -3 | | | | | V | Err | | |
| Photom | etry | | | | | | | | |
| u | | 10 13 | 13.93 -60 | 52 | 38.4 | 12.68 | 0.08 | | |
| | | | | | | | | | |

Table 1.V Sequence of lettered comparison stars for SU Carinae (1010–60 SU Car = HD 88918 (2000) R.A. $10^{h} 13^{m} 30.42^{s}$, Dec. $-60^{\circ} 53' 09.5''$).

Source codes: HIP = Hipparcos (Perryman et al. 1997); T2 = Tycho-2 Catalogue (Høg et al. 2000); 23 = Bateson, F. M., and Menzies, B. 1975, Publ. Var. Star Sec. RASNZ 3, 47; 26 = Menzies, B. 1977, Publ. Var. Star Sec. RASNZ, 5, 6.

| Label | R.A. (2000) | Dec. (2000) | V I | Err Source | |
|-------|-------------|-------------|---------|-----------------|------|
| | h m s | o / ″ | | | |
| u127 | 10 13 13.93 | -60 52 38.4 | 12.68 0 | 0.04 ASAS-3 | |
| v135 | 10 13 21.08 | -60 53 33.3 | 13.54 0 | 0.16 ASAS-3 | |
| w138 | 10 13 19.71 | -60 54 52.9 | 13.8 | Provisional v | |
| x140 | 10 13 38.51 | -60 52 36.8 | 14.0 | Provisional v | |
| y142 | 10 13 13.92 | -60 52 22.5 | 14.2 | Provisional v | |
| z150 | 10 13 22.80 | -60 53 03.6 | 15.0 | Provisional v 1 | red? |

Table 2. Provisional values for the "g" scale chart for SU Car.

Stars "v" to "z" are new, and provisional visual, pending determination of precise values. Star "u" is in the ASAS-3 database and is reliable for visual work.

Note. No ASAS-3 data are available for stars w to z, so the GSC2.2 catalogue (STScI 2001) was examined. However, their V magnitudes (at least those below 13.0) appear to be too bright by about 0.4, so an appropriate adjustment has been made. In view of the uncertainties, the extended provisional sequence is terminated at 15.0v (M.M.).



Figure 1. An excerpt of the AAVSO and RASNZ data (dots) and ASAS data (circles) on SU Car.



Figure 2. The reviewed light curve of SU Car.



Figure 3. The periodogram of SU Car, showing 575.3740 days.



Figure 4(a) The phase diagram of SU Car from the full data set.



Figure 4(b) The phase diagram of SU Car from the edited data set of Figure 2. The scatter in the brighter part of the curve is from a combination of sources. Many more observers have contributed to this part of the curve, each with their inherent scatter, and every maximum is a different peak brightness.



Figure 5. The "g" scale chart for SU Car (previously unpublished). Height of field = 7.5'. Comparison star data are in Table 1.

Recent Minima of 155 Eclipsing Binary Stars

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Received March 7, 2008; revised March 26, 2008, accepted March 26, 2008

Abstract The AAVSO's publication of times of minima for eclipsing binary stars has shifted from the recent publication series, *Observed Minima Timings of Eclipsing Binaries*, Number 1–12, back to the *JAAVSO*. Times of minima from observations made in the past eight months are presented. New light elements for AC CMi have been calculated from recent AAVSO observations:

 $Min(JD) = 2451978.7504 + 0.867216691 E \\ \pm 0.0004 \pm 0.00000024$

1. Background

From 1974 to 1978, the AAVSO Eclipsing Binary Committee published times of minima in the *JAAVSO*. A large increase in observing activity, starting in the mid-1970s, overwhelmed the manual reduction process in place at that time. During the late 1980s, a computer-aided reduction process was developed and the observations were digitized. By this time there was a large backlog of unpublished times of minima.

In *Observed Minima Timings of Eclipsing Binaries*, Number 1–12, published from 1993 to 2007, almost 15,000 times of minima were published by the committee. As a result of this work, all of the legacy data have been reduced and published. The publication of times of minima has now returned to the *JAAVSO*. During these years, the method used to observe eclipsing binary stars has changed from almost 100% visual to almost 100% CCD.

2. Recent Observations

The accompanying list contains times of minima calculated from recent CCD observations made by participants in the AAVSO's eclipsing binary program. This list will be web-archived and available through the AAVSO ftp site at: ftp://ftp.aavso.org/public/datasets/jsamoj362.txt. These observations were reduced by the observers or the writer using the method of Kwee and van Worden (1956). The standard error is included when available.

The linear elements in the 1985 *General Catalogue of Variable Stars* (GCVS; Kholopov *et al.* 1985) were used to compute the O–C values for most stars. For a few exceptions where the GCVS elements are missing or are in significant error, light elements from another source are used: CD Cam (Baldwin and

Samolyk 2007), CW Cas (Samolyk 1992a), Z Dra (Danielkiewicz-Krośniak and Kurpińska-Winiarska 1996), DF Hya (Samolyk 1992b), EF Ori (Baldwin and Samolyk 2005), GU Ori (Samolyk 1985), IP Peg (Baldwin and Samolyk 2000). O–C values listed in this paper can be directly compared with values published in the *Observed Minima Timings* series.

In the case of AC CMi, the linear elements were calculated by linear regression using the times of minima listed in this publication. The following light elements are used:

$$Min (JD) = 2451978.7504 + 0.867216691 E$$
(1)
 $\pm 0.0004 \pm 0.00000024$

The number of observations used for determination of each time of minimum is given under N in Table 1 when available.

This work is sponsored by the AAVSO, with the writer acting as program coordinator.

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| Table 1. Times of | minima of stars in th | e AAVSO eclip | sing binary] | program | J. | | | |
|-------------------|-----------------------|---------------|---------------|---------|------|----------------|-------------------|---|
| Star | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error | 1 |
| RT And | 53722.3598 | 20003 | -0.0063 | 64 | CCD | I. Megson | n/a | |
| RT And | 54394.6834 | 21072 | -0.0083 | 79 | CCD | G. Samolyk | 0.0001 | |
| UU And | 54399.8636 | 8578 | 0.0765 | 75 | CCD | J. Bialozynski | 0.0003 | |
| WZ And | 54380.6141 | 19418 | 0.0448 | 71 | CCD | G. Samolyk | 0.0002 | |
| WZ And | 54423.7439 | 19480 | 0.0439 | 80 | CCD | J. Bialozynski | 0.0002 | |
| WZ And | 54428.6134 | 19487 | 0.0437 | 49 | CCD | K. Menzies | 0.0001 | |
| XZ And | 54381.7406 | 22401 | 0.1646 | 63 | CCD | J. Bialozynski | 0.0001 | |
| XZ And | 54468.6076 | 22465 | 0.1658 | 60 | CCD | J. Bialozynski | 0.0001 | |
| XZ And | 54476.7520 | 22471 | 0.1666 | 24 | CCD | E. Wiley | 0.0006 | |
| AB And | 54372.7552 | 55027.5 | -0.0194 | 50 | CCD | G. Samolyk | 0.0003 | |
| AB And | 54420.5476 | 55171.5 | -0.0194 | 87 | CCD | G. Samolyk | 0.0001 | |
| AB And | 54442.6171 | 55238 | -0.0208 | 62 | CCD | J. Bialozynski | 0.0001 | |
| AB And | 54466.5134 | 55310 | -0.0207 | 33 | CCD | K. Menzies | 0.0002 | |
| AD And | 54372.7593 | 15585.5 | -0.0469 | 62 | CCD | G. Samolyk | 0.0004 | |
| AD And | 54414.6727 | 15628 | -0.0469 | 62 | CCD | G. Samolyk | 0.0006 | |
| BX And | 54468.5623 | 29404 | -0.0469 | 107 | CCD | G. Samolyk | 0.0002 | |
| DS And | 54338.8179 | 18007 | 0.0013 | 62 | CCD | G. Samolyk | 0.0005 | |
| DS And | 54424.7122 | 18092 | 0.0015 | 80 | CCD | J. Bialozynski | 0.0003 | |
| RY Aqr | 54401.6943 | 6904 | -0.0847 | 90 | CCD | J. Bialozynski | 0.0002 | |
| CX Aqr | 54384.6757 | 32251 | 0.0098 | 57 | CCD | J. Bialozynski | 0.0002 | |

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| Table 1. Times of | minima of stars in th | e AAVSO eclij | osing binary | program | ı, cont. | | | |
|-------------------|-----------------------|---------------|--------------|---------|----------|----------------|-------------------|---|
| Star | HJD(min) 2400000+ | Cycle | 0-C | N | Type | Observer | Standard Error | 1 |
| CZ Aqr | 54452.6427 | 12844 | -0.0387 | 60 | CCD | J. Bialozynski | 0.0001 | 1 |
| XZ Aql | 54338.6676 | 5813 | 0.1474 | 106 | CCD | G. Samolyk | 0.0001 | |
| V343 Aql | 54363.7318 | 14052 | -0.0466 | 80 | CCD | J. Bialozynski | 0.0005 | |
| RX Ari | 54388.7240 | 15530 | 0.0625 | 78 | CCD | J. Bialozynski | 0.0007 | |
| RX Ari | 54451.5281 | 15591 | 0.0594 | 85 | CCD | G. Samolyk | 0.0003 | |
| SS Ari | 54414.6971 | 37898.5 | -0.2463 | 73 | CCD | G. Samolyk | 0.0003 | |
| RY Aur | 54475.6830 | 5939 | 0.0229 | 120 | CCD | J. Bialozynski | 0.0004 | |
| SX Aur | 54437.6653 | 11797 | 0.0137 | 74 | CCD | R. Poklar | 0.0007 | |
| TT Aur | 54480.6554 | 24940 | -0.0119 | 89 | CCD | J. Bialozynski | 0.0002 | |
| WW Aur | 54477.6433 | 8527.5 | 0.0026 | 06 | CCD | J. Bialozynski | 0.0008 | |
| WW Aur | 54506.6809 | 8539 | 0.0025 | 95 | CCD | J. Bialozynski | 0.0010 | |
| AP Aur | 54429.6680 | 21051.5 | 1.1769 | 57 | CCD | G. Samolyk | 0.0004 | |
| AP Aur | 54452.7241 | 21092 | 1.1759 | 80 | CCD | R. Poklar | 0.0003 | |
| AP Aur | 54505.6773 | 21185 | 1.1830 | 59 | CCD | K. Menzies | 0.0002 | |
| AP Aur | 54517.6343 | 21206 | 1.1844 | 104 | CCD | G. Samolyk | 0.0004 | |
| AP Aur | 54522.7582 | 21215 | 1.1845 | 80 | CCD | J. Bialozynski | 0.0004 | |
| AR Aur | 54475.6904 | 3887.5 | -0.1196 | 100 | CCD | J. Bialozynski | 0.0008 | |
| AR Aur | 54504.6330 | 3894.5 | -0.1199 | 86 | CCD | J. Bialozynski | 0.0009 | |
| CL Aur | 54483.6929 | 17291 | 0.1243 | 83 | CCD | J. Bialozynski | 0.0002 | |
| EM Aur | 54476.6524 | 12889.5 | -0.1853 | 75 | CCD | J. Bialozynski | 0.0006 | |

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Table continued on following pages
| Table 1. Times of n | ninima of stars in th | e AAVSO eclip | ising binary l | program | ı, cont. | | | |
|---------------------|-----------------------|---------------|----------------|---------|----------|----------------|-------------------|--|
| Star | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error | |
| EP Aur | 54520.5706 | 47734 | 0.0127 | 90 | CCD | G. Samolyk | 0.0001 | |
| HP Aur | 54380.7840 | 8170 | 0.0527 | 63 | CCD | G. Samolyk | 0.0002 | |
| HP Aur | 54447.6580 | 8217 | 0.0544 | 83 | CCD | R. Poklar | 0.0001 | |
| HP Aur | 54506.7046 | 8258.5 | 0.0543 | 60 | CCD | J. Bialozynski | 0.0002 | |
| TU Boo | 54520.7686 | 66159 | -0.1258 | 94 | CCD | G. Samolyk | 0.0001 | |
| Y Cam | 54366.6551 | 3450 | 0.3234 | 151 | CCD | G. Samolyk | 0.0003 | |
| Y Cam | 54452.6082 | 3476 | 0.3302 | 162 | CCD | G. Samolyk | 0.0001 | |
| SV Cam | 54338.6359 | 19802 | 0.0496 | 99 | CCD | G. Samolyk | 0.0002 | |
| SV Cam | 54440.6454 | 19974 | 0.0510 | 65 | CCD | R. Poklar | 0.0001 | |
| AL Cam | 54420.7275 | 21086 | -0.0325 | 110 | CCD | G. Samolyk | 0.0001 | |
| CD Cam | 54402.6350 | 2146 | -0.0028 | 147 | CCD | G. Samolyk | 0.0006 | |
| CD Cam | 54403.7855 | 2147.5 | 0.0014 | 150 | CCD | G. Samolyk | 0.0005 | |
| R CMa | 54461.7911 | 8955 | 0.0829 | 79 | CCD | J. Bialozynski | 0.0007 | |
| RT CMa | 54505.6560 | 21550 | -0.6776 | 76 | CCD | J. Bialozynski | 0.0001 | |
| TU CMa | 54485.7053 | 24391 | -0.0095 | 80 | CCD | J. Bialozynski | 0.0002 | |
| TU CMa | 54520.6678 | 24422 | -0.0089 | 123 | CCD | G. Samolyk | 0.0003 | |
| TZ CMa | 54494.6653 | 14319 | -0.2010 | 79 | CCD | J. Bialozynski | 0.0003 | |
| TZ CMa | 54517.6023 | 14331 | -0.2013 | 111 | CCD | G. Samolyk | 0.0002 | |
| UU CMa | 54505.6372 | 4573 | -0.1070 | 88 | CCD | J. Bialozynski | 0.0001 | |
| XZ CMi | 54487.6820 | 20807 | -0.0090 | 59 | CCD | J. Bialozynski | 0.0003 | |

| Table 1. Times of n | ninima of stars in th | e AAVSO eclip | sing binary l | program | ı, cont. | | | |
|---------------------|-----------------------|---------------|---------------|---------|----------|----------------|-------------------|----|
| Star | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error | I. |
| XZ CMi | 54513.7296 | 20852 | -0.0078 | 57 | CCD | K. Menzies | 0.0002 | 1 |
| AC CMi | 51978.7504 | 0 | 0.0000 | 44 | CCD | C. Hesseltine | 0.0003 | |
| AC CMI | 52311.7600 | 384 | -0.0016 | 67 | CCD | G. Samolyk | 0.0002 | |
| AC CMI | 53393.6142 | 1631.5 | -0.0002 | 39 | CCD | G. Samolyk | 0.0008 | |
| AC CMi | 53438.7097 | 1683.5 | 0.0000 | 50 | CCD | G. Samolyk | 0.0002 | |
| AC CMI | 54156.7652 | 2511.5 | 0.0001 | 75 | CCD | J. Bialozynski | 0.0003 | |
| AC CMI | 54499.7505 | 2907 | 0.0012 | 100 | CCD | J. Bialozynski | 0.0002 | |
| AC CMI | 54513.6249 | 2923 | 0.0001 | 65 | CCD | K. Menzies | 0.0001 | |
| AK CMi | 54485.8144 | 20117 | -0.0176 | 86 | CCD | G. Samolyk | 0.0002 | |
| AK CMi | 54497.6981 | 20138 | -0.0178 | 80 | CCD | J. Bialozynski | 0.0002 | |
| AK CMi | 54513.5450 | 20166 | -0.0160 | 56 | CCD | G. Samolyk | 0.0003 | |
| AM CMi | 54504.6457 | 28709 | 0.1818 | 94 | CCD | J. Bialozynski | 0.0008 | |
| TY Cap | 54384.7168 | 6738 | 0.0600 | 80 | CCD | J. Bialozynski | 0.0004 | |
| RZ Cas | 54392.6560 | 9364 | 0.0568 | 73 | CCD | J. Bialozynski | 0.0002 | |
| TV Cas | 54406.7609 | 5409 | -0.0221 | 80 | CCD | J. Bialozynski | 0.0006 | |
| AB Cas | 54372.6209 | 8529 | 0.0916 | 95 | CCD | G. Samolyk | 0.0002 | |
| AB Cas | 54391.7572 | 8543 | 0.0916 | 80 | CCD | J. Bialozynski | 0.0002 | |
| CW Cas | 54366.7774 | 39937.5 | -0.0426 | 54 | CCD | G. Samolyk | 0.0001 | |
| DZ Cas | 54401.7355 | 33084 | -0.1742 | 89 | CCD | J. Bialozynski | 0.0005 | |
| DZ Cas | 54449.6150 | 33145 | -0.1731 | 79 | CCD | J. Bialozynski | 0.0006 | |

| Table 1. Times of n | ninima of stars in th | e AAVSO eclip | sing binary p | orogram | l, cont. | | | |
|---------------------|-----------------------|---------------|---------------|---------|----------|----------------|-------------------|----|
| Star | HJD(min) 2400000+ | Cycle | 0-C | N | Type | Observer | Standard Error | 1 |
| IR Cas | 54380.8845 | 17654 | 0.0104 | 47 | CCD | G. Samolyk | 0.0002 | i. |
| IS Cas | 54391.7616 | 13910 | 0.0611 | 98 | CCD | J. Bialozynski | 0.0006 | |
| IT Cas | 54390.6820 | 6577 | 0.0599 | 98 | CCD | J. Bialozynski | 0.0001 | |
| MM Cas | 54380.7837 | 16383 | 0.0867 | 85 | CCD | J. Bialozynski | 0.0002 | |
| OR Cas | 54392.8142 | 8174 | -0.0214 | 70 | CCD | J. Bialozynski | 0.0001 | |
| OX Cas | 54389.7723 | 5270.5 | 0.0561 | 100 | CCD | J. Bialozynski | 0.0002 | |
| PV Cas | 54381.6699 | 8086 | -0.0338 | 64 | CCD | J. Bialozynski | 0.0003 | |
| V364 Cas | 54394.7033 | 13001 | -0.0218 | 94 | CCD | H. Gerner | 0.0002 | |
| V364 Cas | 54469.5413 | 13049.5 | -0.0226 | 95 | CCD | G. Samolyk | 0.0001 | |
| V375 Cas | 54382.7823 | 13398 | 0.1243 | 67 | CCD | J. Bialozynski | 0.0009 | |
| V380 Cas | 54389.7703 | 21178 | -0.0623 | 100 | CCD | J. Bialozynski | 0.0002 | |
| U Cep | 54386.8068 | 3949 | 0.1591 | 128 | CCD | G. Samolyk | 0.0001 | |
| SU Cep | 54407.7197 | 31154 | 0.0048 | 80 | CCD | J. Bialozynski | 0.0004 | |
| WZ Cep | 54338.8138 | 62998 | -0.0746 | 70 | CCD | G. Samolyk | 0.0002 | |
| WZ Cep | 54366.7809 | 63065 | -0.0765 | 67 | CCD | G. Samolyk | 0.0002 | |
| XX Cep | 54380.7457 | 4082 | -0.0237 | 80 | CCD | J. Bialozynski | 0.0004 | |
| ZZ Cep | 54409.6537 | 12364 | -0.0125 | 94 | CCD | J. Bialozynski | 0.0004 | |
| DK Cep | 54429.6990 | 21137 | 0.0324 | 37 | CCD | G. Samolyk | 0.0004 | |
| EG Cep | 54394.7181 | 21667 | 0.0144 | 99 | CCD | G. Samolyk | 0.0001 | |
| EG Cep | 54429.5738 | 21731 | 0.0143 | 58 | CCD | G. Samolyk | 0.0001 | |

| Table 1. Times of m | inima of stars in the | e AAVSO eclip | ising binary l | program | l, cont. | | | |
|---------------------|-----------------------|---------------|----------------|---------|----------|----------------|-------------------|---|
| Star | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error | 1 |
| EK Cep | 54362.7465 | 3469 | 0.0100 | 89 | CCD | J. Bialozynski | 0.0001 | |
| SS Cet | 54394.8250 | 4016 | 0.0084 | 103 | CCD | G. Samolyk | 0.0002 | |
| SS Cet | 54409.6953 | 4021 | 0.0088 | 95 | CCD | J. Bialozynski | 0.0002 | |
| TT Cet | 54380.7744 | 44932 | -0.0531 | 60 | CCD | G. Samolyk | 0.0003 | |
| TT Cet | 54419.6473 | 45012 | -0.0567 | 69 | CCD | R. Poklar | 0.0002 | |
| TT Cet | 54449.7768 | 45074 | -0.0565 | 57 | CCD | J. Bialozynski | 0.0002 | |
| TW Cet | 54390.7538 | 37927.5 | -0.0246 | 60 | CCD | J. Bialozynski | 0.0001 | |
| TW Cet | 54450.6386 | 38116.5 | -0.0248 | LL | CCD | R. Poklar | 0.0002 | |
| TX Cet | 54416.7613 | 15299 | 0.0120 | 79 | CCD | J. Bialozynski | 0.0006 | |
| TX Cet | 54448.6166 | 15342 | 0.0112 | 85 | CCD | R. Poklar | 0.0002 | |
| RW Com | 54520.7893 | 61085.5 | -0.0200 | 89 | CCD | G. Samolyk | 0.0002 | |
| W Crv | 54519.8141 | 38322 | 0.0145 | 88 | CCD | G. Samolyk | 0.0002 | |
| ZZ Cyg | 54378.6335 | 14919 | -0.0522 | n/a | CCD | R. Crumrine | 0.0001 | |
| ZZ Cyg | 54429.5529 | 15000 | -0.0507 | 71 | CCD | G. Samolyk | 0.0002 | |
| CG Cyg | 54394.5826 | 23718 | 0.0583 | LL | CCD | H. Gerner | 0.0001 | |
| DK Cyg | 54372.6314 | 34785 | 0.0768 | 92 | CCD | G. Samolyk | 0.0004 | |
| DK Cyg | 54378.7494 | 34798 | 0.0758 | 57 | CCD | J. Bialozynski | 0.0002 | |
| DK Cyg | 54380.6333 | 34802 | 0.0770 | 76 | CCD | H. Gerner | 0.0001 | |
| DK Cyg | 54429.5880 | 34906 | 0.0799 | 63 | CCD | G. Samolyk | 0.0002 | |
| V387 Cyg | 54378.6909 | 41201 | 0.0176 | 57 | CCD | J. Bialozynski | 0.0002 | |

| Table 1. Times of n | ninima of stars in th | e AAVSO eclip | sing binary p | rogram | ı, cont. | | | |
|---------------------|-----------------------|---------------|---------------|--------|----------|----------------|-------------------|--|
| Star | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error | |
| V704 Cyg | 54394.5501 | 28833 | 0.0327 | 67 | CCD | G. Samolyk | 0.0002 | |
| TT Del | 54379.7186 | 3186 | -0.0855 | 95 | CCD | J. Bialozynski | 0.0003 | |
| FZ Del | 54394.6016 | 29456 | -0.0377 | 81 | CCD | G. Samolyk | 0.0001 | |
| Z Dra | 54372.7747 | 3336 | -0.0318 | 61 | CCD | G. Samolyk | 0.0001 | |
| S Equ | 54406.6739 | 3437 | 0.0654 | 95 | CCD | J. Bialozynski | 0.0001 | |
| S Equ | 54437.5986 | 3446 | 0.0652 | 80 | CCD | J. Bialozynski | 0.0002 | |
| TZ Eri | 54480.6219 | 4630 | 0.2766 | 69 | CCD | J. Bialozynski | 0.0002 | |
| YY Eri | 54394.7384 | 39854.5 | 0.1258 | 67 | CCD | G. Samolyk | 0.0002 | |
| YY Eri | 54418.6894 | 39929 | 0.1255 | 25 | CCD | J. Bialozynski | 0.0003 | |
| YY Eri | 54422.7084 | 39941.5 | 0.1258 | 59 | CCD | J. Bialozynski | 0.0003 | |
| YY Eri | 54456.6265 | 40047 | 0.1263 | 62 | CCD | R. Poklar | 0.0002 | |
| YY Eri | 54490.5453 | 40152.5 | 0.1274 | 101 | CCD | G. Samolyk | 0.0002 | |
| YY Eri | 54517.5497 | 40236.5 | 0.1263 | 79 | CCD | G. Samolyk | 0.0002 | |
| RW Gem | 54453.7710 | 12616 | 0.0033 | 100 | CCD | J. Bialozynski | 0.0006 | |
| RW Gem | 54476.6932 | 12624 | 0.0015 | 100 | CCD | J. Bialozynski | 0.0006 | |
| RW Gem | 54519.6755 | 12639 | 0.0014 | 135 | CCD | G. Samolyk | 0.0001 | |
| SX Gem | 54516.7040 | 25961 | -0.0598 | 66 | CCD | J. Bialozynski | 0.0002 | |
| TX Gem | 54453.7593 | 12359 | -0.0257 | 120 | CCD | J. Bialozynski | 0.0002 | |
| TX Gem | 54495.7590 | 12374 | -0.0262 | 120 | CCD | J. Bialozynski | 0.0003 | |
| WW Gem | 54380.9063 | 22941 | 0.0271 | 57 | CCD | G. Samolyk | 0.0005 | |

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| Table 1. Times of | minima of stars in th | e AAVSO eclip | sing binary p | orogram | l, cont. | | | |
|-------------------|-----------------------|---------------|---------------|---------|----------|----------------|-------------------|---|
| Star | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error | 1 |
| WW Gem | 54421.7597 | 22974 | 0.0328 | 62 | CCD | J. Bialozynski | 0.0003 | |
| WW Gem | 54483.6501 | 23024 | 0.0326 | 78 | CCD | J. Bialozynski | 0.0005 | |
| AF Gem | 54485.7465 | 21973 | -0.0650 | 80 | CCD | J. Bialozynski | 0.0001 | |
| AL Gem | 54497.7243 | 20249 | 0.0643 | 79 | CCD | J. Bialozynski | 0.0001 | |
| SZ Her | 54356.6452 | 15270 | -0.0207 | 88 | CCD | R. Baker | 0.0006 | |
| AV Hya | 54513.6047 | 26105 | -0.0902 | 43 | CCD | S. Diesso | 0.0003 | |
| DF Hya | 54519.6196 | 35486 | -0.0139 | 75 | CCD | G. Samolyk | 0.0010 | |
| SW Lac | 54380.6729 | 28390.5 | -0.1015 | 79 | CCD | G. Samolyk | 0.0004 | |
| VX Lac | 54460.4960 | 8564 | 0.0617 | 35 | CCD | K. Menzies | 0.0001 | |
| CO Lac | 54370.8020 | 17401.5 | 0.0054 | 95 | CCD | J. Bialozynski | 0.0002 | |
| CO Lac | 54380.8111 | 17408 | -0.0099 | 103 | CCD | G. Samolyk | 0.0003 | |
| DG Lac | 54396.6511 | 4481 | -0.2148 | 80 | CCD | J. Bialozynski | 0.0005 | |
| UU Leo | 54496.7665 | 5417 | 0.1540 | 69 | CCD | J. Bialozynski | 0.0001 | |
| UV Leo | 54506.8273 | 26773 | 0.0312 | 139 | CCD | G. Samolyk | 0.0001 | |
| RR Lep | 54454.7186 | 26302 | -0.0307 | 78 | CCD | R. Poklar | 0.0006 | |
| RR Lep | 54465.7039 | 26314 | -0.0305 | 73 | CCD | J. Bialozynski | 0.0003 | |
| RR Lep | 54487.6739 | 26338 | -0.0308 | 60 | CCD | J. Bialozynski | 0.0007 | |
| RR Lep | 54520.6271 | 26374 | -0.0330 | 91 | CCD | G. Samolyk | 0.0003 | |
| RY Lyn | 54513.6675 | 8102 | -0.0483 | 80 | CCD | J. Bialozynski | 0.0001 | |
| EW Lyr | 54366.6716 | 14300 | 0.2357 | 76 | CCD | G. Samolyk | 0.0001 | |

| Table 1. Times of n | ninima of stars in th | e AAVSO eclip | sing binary J | program | l, cont. | | |
|---------------------|-----------------------|---------------|---------------|---------|----------|----------------|-------------------|
| Star | HJD(min) 2400000+ | Cycle | 0-C | N | Type | Observer | Standard Error |
| RU Mon | 54484.6855 | 3554.5 | -0.4995 | 100 | CCD | J. Bialozynski | 0.0003 |
| RW Mon | 54458.7160 | 10901 | -0.0641 | 94 | CCD | J. Bialozynski | 0.0001 |
| RW Mon | 54498.7434 | 10922 | -0.0647 | 100 | CCD | J. Bialozynski | 0.0001 |
| AT Mon | 54516.6771 | 13755 | 0.0070 | 100 | CCD | J. Bialozynski | 0.0005 |
| BB Mon | 54508.7262 | 37979 | -0.0043 | 80 | CCD | J. Bialozynski | 0.0004 |
| EP Mon | 54525.6917 | 18846 | 0.0363 | 100 | CCD | J. Bialozynski | 0.0004 |
| EF Ori | 54460.7330 | 1303 | 0.0010 | 118 | CCD | J. Bialozynski | 0.0005 |
| EF Ori | 54507.6981 | 1332 | 0.0022 | 116 | CCD | J. Bialozynski | 0.0004 |
| EF Ori | 54520.6529 | 1340 | 0.0014 | 127 | CCD | G. Samolyk | 0.0002 |
| EQ Ori | 54458.7284 | 13184 | -0.0301 | 78 | CCD | J. Bialozynski | 0.0001 |
| EQ Ori | 54507.6179 | 13212 | -0.0302 | 70 | CCD | J. Bialozynski | 0.0001 |
| ER Ori | 54394.9061 | 30157 | 0.0565 | 46 | CCD | G. Samolyk | 0.0002 |
| ER Ori | 54497.5854 | 30399.5 | 0.0616 | 35 | CCD | K. Menzies | 0.0003 |
| ER Ori | 54513.6747 | 30437.5 | 0.0618 | 99 | CCD | J. Bialozynski | 0.0002 |
| ET Ori | 54508.6581 | 29260 | -0.0006 | 87 | CCD | J. Bialozynski | 0.0001 |
| FH Ori | 54514.7753 | 13302 | -0.3420 | 100 | CCD | J. Bialozynski | 0.0001 |
| FT Ori | 54460.7240 | 4162 | 0.0134 | 80 | CCD | J. Bialozynski | 0.0001 |
| FT Ori | 54523.7326 | 4182 | 0.0137 | 80 | CCD | J. Bialozynski | 0.0001 |
| FZ Ori | 54495.6468 | 26179 | -0.0607 | 63 | CCD | R. Poklar | 0.0002 |
| GU Ori | 54496.5837 | 24277 | -0.0419 | 104 | CCD | G. Samolyk | 0.0002 |

| Table 1. Times of m | inima of stars in the | e AAVSO eclip | sing binary] | program | l, cont. | | | |
|---------------------|-----------------------|---------------|---------------|---------|----------|----------------|-------------------|---|
| Star | HJD(min) 2400000+ | Cycle | 0-C | N | Type | Observer | Standard Error | |
| GU Ori | 54520.5873 | 24328 | -0.0431 | 127 | CCD | G. Samolyk | 0.0002 | 1 |
| U Peg | 54388.6222 | 47700 | -0.1207 | n/a | CCD | R. Sabo | 0.0007 | |
| U Peg | 54429.6620 | 47809.5 | -0.1194 | 48 | CCD | G. Samolyk | 0.0003 | |
| U Peg | 54440.5305 | 47838.5 | -0.1196 | 91 | CCD | G. Samolyk | 0.0001 | |
| TY Peg | 54338.6474 | 4491 | -0.2966 | 55 | CCD | G. Samolyk | 0.0002 | |
| UX Peg | 54385.7193 | 9038 | -0.0081 | 84 | CCD | J. Bialozynski | 0.0001 | |
| AQ Peg | 54339.8352: | 2364 | 0.4698 | 103 | CCD | C. Hesseltine | 0.0009 | |
| BB Peg | 54366.6477 | 29328.5 | 0.0000 | 42 | CCD | G. Samolyk | 0.0003 | |
| BG Peg | 54372.6314 | 4528 | -1.8028 | 115 | CCD | G. Samolyk | 0.0003 | |
| BX Peg | 54386.6281 | 36343 | -0.0821 | 55 | CCD | G. Samolyk | 0.0004 | |
| BX Peg | 54420.5567 | 36464 | -0.0845 | 67 | CCD | G. Samolyk | 0.0002 | |
| DI Peg | 54394.5693 | 12922 | -0.0154 | 58 | CCD | G. Samolyk | 0.0001 | |
| DI Peg | 54416.6361 | 12953 | -0.0149 | 45 | CCD | J. Bialozynski | 0.0001 | |
| GP Peg | 54429.6149 | 13521 | -0.0427 | 64 | CCD | H. Gerner | 0.0002 | |
| IP Peg | 54413.4146 | 28107 | -0.0023 | 43 | CCD | F. Salvaggio | 0.0003 | |
| V357 Peg | 54061.5419 | 2699 | 0.0007 | n/a | CCD | V. Petriew | 0.0005 | |
| V357 Peg | 54064.7235 | 2704.5 | 0.0008 | n/a | CCD | V. Petriew | 0.0003 | |
| V357 Peg | 54375.3503 | 3241.5 | -0.0005 | 550 | CCD | F. Salvaggio | 0.0001 | |
| Z Per | 54482.5843 | 2887 | -0.2179 | 55 | CCD | K. Menzies | 0.0001 | |
| Z Per | 54485.6404 | 2888 | -0.2181 | 110 | CCD | G. Samolyk | 0.0002 | |

| Table 1. Times of 1 | minima of stars in th | e AAVSO ecliț | sing binary p | rogram | ı, cont. | | |
|---------------------|-----------------------|---------------|---------------|--------|----------|----------------|-------------------|
| Star | HJD(min) 2400000+ | Cycle | 0-C | N | Type | Observer | Standard Error |
| RT Per | 54370.7444 | 24717 | 0.0584 | 65 | CCD | J. Bialozynski | 0.0002 |
| RT Per | 54466.7279 | 24830 | 0.0596 | 25 | CCD | E. Wiley | 0.0003 |
| RV Per | 54420.7123 | 6270 | -0.0010 | 98 | CCD | G. Samolyk | 0.0001 |
| ST Per | 54372.7514 | 4507 | 0.2877 | 68 | CCD | G. Samolyk | 0.0003 |
| XZ Per | 54476.7360 | 9525 | -0.0564 | 49 | CCD | E. Wiley | 0.0003 |
| XZ Per | 54521.6495 | 9564 | -0.0566 | 80 | CCD | J. Bialozynski | 0.0001 |
| KW Per | 54387.7810 | 12868 | 0.0102 | 79 | CCD | J. Bialozynski | 0.0001 |
| KW Per | 54429.6882 | 12913 | 0.0108 | 89 | CCD | R. Poklar | 0.0002 |
| KW Per | 54524.6764 | 13015 | 0.0106 | 80 | CCD | J. Bialozynski | 0.0001 |
| Y Psc | 54405.7122 | 2329 | -0.0001 | 83 | CCD | G. Samolyk | 0.0003 |
| UZ Pup | 54495.6795 | 12432.5 | -0.0063 | 80 | CCD | J. Bialozynski | 0.0002 |
| UZ Pup | 54513.5632 | 12455 | -0.0068 | 84 | CCD | G. Samolyk | 0.0002 |
| UZ Pup | 54518.7305 | 12461.5 | -0.0060 | 80 | CCD | J. Bialozynski | 0.0002 |
| UZ Pup | 54520.7153 | 12464 | -0.0083 | 104 | CCD | S. Diesso | 0.0003 |
| UZ Pup | 54520.7164 | 12464 | -0.0072 | 82 | CCD | J. Bialozynski | 0.0002 |
| RW Tau | 54380.8931 | 3141 | -0.2235 | 105 | CCD | G. Samolyk | 0.0001 |
| RW Tau | 54405.8130 | 3150 | -0.2231 | 144 | CCD | G. Samolyk | 0.0001 |
| RW Tau | 54419.6567 | 3155 | -0.2236 | 80 | CCD | J. Bialozynski | 0.0001 |
| RW Tau | 54466.7268 | 3172 | -0.2237 | 24 | CCD | E. Wiley | 0.0004 |
| RZ Tau | 54366.7920 | 40152 | 0.0544 | 34 | CCD | G. Samolyk | 0.0003 |

| r HJD(min) Cycle $O-C$ N Type Observer Stand au 5448.5830 40445 0.0528 107 CCD G. Samolyk 0.00 au 5451.5233 40505 0.0526 64 CCD K. Menzies 0.00 au 5457.7937 4317 0.0359 30 CCD J. Bialozynski 0.00 au 54457.7937 4317 0.0359 30 CCD J. Bialozynski 0.00 au 54457.7937 4317 0.0355 n/a CCD J. Bialozynski 0.00 au 54447.4029 16267 0.6660 79 CCD J. Bialozynski 0.00 au 54447.4029 16267 0.6660 79 CCD J. Bialozynski 0.00 au 54447.4029 16267 0.6660 79 CCD J. Bialozynski 0.00 au 54447.4029 16267 0.6660 79 CCD J. Bialozynski | Times of r | ninima of stars in th | e AAVSO eclip | sing binary ₁ | program | l, cont. | | |
|---|------------|-----------------------|---------------|--------------------------|---------|----------|----------------|-------------------|
| 54488.583040445 0.0528 107 CCD $G. Samolyk$ 0.00 54513.523340505 0.02226 64 CCD $K.$ Menzies 0.00 545520.634830935 0.2474 40 CCD $J.$ Bialozynski 0.00 54457.79374317 0.03558 125 CCD $J.$ Bialozynski 0.00 54457.79374317 0.03558 125 CCD $J.$ Bialozynski 0.00 54496.6175 4374 -0.0525 n/a CCD $J.$ Bialozynski 0.00 54437.759 13784 -0.027 13 CCD $R.$ Sabo 0.00 54437.559 13784 -0.027 13 CCD $R.$ Salvaggio 0.00 54437.559 13784 -0.027 13 CCD $J.$ Bialozynski 0.00 54439.6820 20432 0.5575 99 CCD $J.$ Bialozynski 0.00 54439.6820 20432 0.5575 99 CCD $J.$ Bialozynski 0.00 54421.7588 41624.5 -0.0257 91 CCD $J.$ Bialozynski 0.00 54432.5502 41744 -0.0257 91 CCD $J.$ Bialozynski 0.00 54432.7187 6401 0.0257 91 CCD $J.$ Bialozynski 0.00 54432.5502 41744 -0.0257 91 CCD $J.$ Bialozynski 0.00 54435.6628 51198 -0.0257 91 CCD $J.$ Bialozynski 0.00 | | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error |
| 54513.5233 40505 0.0526 64 CCD K. Menzies 0.00 54520.6348 30935 0.2474 40 CCD J. Bialozynski 0.00 5457.7937 4317 0.0358 125 CCD J. Bialozynski 0.00 54457.7937 4317 0.0359 30 CCD J. Bialozynski 0.00 54457.7937 4336 0.0355 n/a CCD J. Bialozynski 0.00 54496.6175 4336 0.0355 n/a CCD J. Bialozynski 0.00 54437.599 13784 -0.0277 13 CCD R. Sabo 0.00 1 54447.4029 16267 0.6660 79 CCD J. Bialozynski 0.00 1 54443.7029 15267 0.6660 79 CCD J. Bialozynski 0.00 1 544447.4029 16267 0.6660 79 CCD J. Bialozynski 0.00 54447.4029 16267 0.6660 79 | | 54488.5830 | 40445 | 0.0528 | 107 | CCD | G. Samolyk | 0.0001 |
| 54520.6348 30935 0.2474 40 CCD J. Bialozynski 0.00 54457.7937 4317 0.0358 125 CCD J. Bialozynski 0.00 54457.7937 4317 0.0358 125 CCD J. Bialozynski 0.00 54496.6175 4336 0.0359 30 CCD J. Bialozynski 0.00 54497.7937 4374 -0.0525 n/a CCD J. Bialozynski 0.00 54397.8894 4474 -0.0525 n/a CCD R. Sabo 0.00 54397.8894 1474 -0.027 13 CCD S. Look n/a 54447.4029 16267 0.6660 79 CCD J. Bialozynski 0.00 54448.6820 20431.7588 41624.5 -0.0257 94 CCD J. Bialozynski 0.00 54432.7187 6401 0.0224 119 CCD J. Bialozynski 0.00 54442.5502 41744 -0.0257 91 CCD< | _ | 54513.5233 | 40505 | 0.0526 | 64 | CCD | K. Menzies | 0.0001 |
| 1 54457.7937 4317 0.0358 125 CCD J. Bialozynski 0.00 1 54496.6175 4336 0.0359 30 CCD J. Bialozynski 0.00 1 54496.6175 4374 -0.0525 n/a CCD J. Bialozynski 0.00 1 50437.559 13784 -0.0277 13 CCD R. Sabo 0.00 1 50437.559 13784 -0.0277 13 CCD S. Cook n/a 1 544474.2029 16267 0.6660 79 CCD J. Bialozynski 0.00 1 544398.6820 20432 0.5575 99 CCD J. Bialozynski 0.00 544398.6820 200479 94 CCD J. Bialozynski 0.00 544321.7588 41624.5 -0.0257 91 CCD J. Bialozynski 0.00 1 54437.7187 6401 0.0224 119 <td< td=""><td>_</td><td>54520.6348</td><td>30935</td><td>0.2474</td><td>40</td><td>CCD</td><td>J. Bialozynski</td><td>0.0002</td></td<> | _ | 54520.6348 | 30935 | 0.2474 | 40 | CCD | J. Bialozynski | 0.0002 |
| 1 54496.6175 4336 0.0359 30 CCD J. Bialozynski 0.00 1 54397.8894 4474 -0.0525 n/a CCD R. Sabo 0.00 1 50437.559 13784 -0.027 13 CCD R. Sabo 0.00 1 50437.559 13784 -0.027 13 CCD S. Cook n/a 1 54447.4029 16267 0.6660 79 CCD S. Cook n/a 54448.6820 20432 0.5575 99 CCD J. Bialozynski 0.00 1 54498.6820 20432 0.5575 94 CCD J. Bialozynski 0.00 1 54498.6820 20437 41381.5 -0.0257 91 CCD J. Bialozynski 0.00 1 54437.7187 6401 0.0224 119 CCD J. Bialozynski 0.00 1 54462.5502 41744 -0.0257 91 CCD J. Bialozynski 0.00 <td>1</td> <td>54457.7937</td> <td>4317</td> <td>0.0358</td> <td>125</td> <td>CCD</td> <td>J. Bialozynski</td> <td>0.0002</td> | 1 | 54457.7937 | 4317 | 0.0358 | 125 | CCD | J. Bialozynski | 0.0002 |
| u 54397.8894 4474 -0.0525 n/a CCD R. Sabo 0.00 1 50437.559 13784 -0.027 13 CCD S. Cook n/a 1 54447.4029 16267 0.6660 79 CCD S. Cook n/a 1 54447.4029 16267 0.6660 79 CCD J. Bialozynski 0.00 1 54498.6820 20432 0.5575 99 CCD J. Bialozynski 0.00 1 54498.6820 20432 0.0254 81 CCD J. Bialozynski 0.00 1 54431.7187 6401 0.0224 119 CCD J. Bialozynski 0.00 1 54462.5502 41744 -0.0257 91 CCD J. Bialozynski 0.00 1 54462.5502 41744 -0.0257 91 CCD J. Bialozynski 0.00 54446.55502 64110 0.02214 119 | T | 54496.6175 | 4336 | 0.0359 | 30 | CCD | J. Bialozynski | 0.0009 |
| 1 50437.559 13784 -0.027 13 CCD S. Cook n/a 1 54447.4029 16267 0.6660 79 CCD S. Cook n/a 1 54447.4029 16267 0.6660 79 CCD F. Salvaggio 0.00 1 54498.6820 20432 0.5575 99 CCD J. Bialozynski 0.00 1 54498.6820 20432 0.5575 99 CCD J. Bialozynski 0.00 1 5439.8518 113410 -0.0254 81 CCD G. Samolyk 0.00 54421.7588 41624.5 -0.0257 91 CCD J. Bialozynski 0.00 544421.7588 41624.5 -0.0257 91 CCD J. Bialozynski 0.00 1 54462.5502 41744 -0.0224 119 CCD J. Bialozynski 0.00 54455.6628 51198 -0.0023 58 CCD J. Bialozynski 0.00 54435.66 | n | 54397.8894 | 4474 | -0.0525 | n/a | CCD | R. Sabo | 0.0001 |
| 1 54447.4029 16267 0.6660 79 CCD F. Salvaggio 0.00 1 54498.6820 20432 0.5575 99 CCD J. Bialozynski 0.00 1 54399.8518 13490 -0.0479 94 CCD J. Bialozynski 0.00 1 54399.8518 13490 -0.0479 94 CCD J. Bialozynski 0.00 1 54399.8518 1381.5 -0.0254 81 CCD J. Bialozynski 0.00 1 54421.7588 41624.5 -0.0257 91 CCD J. Bialozynski 0.00 1 54442.5502 41744 -0.0257 91 CCD J. Bialozynski 0.00 1 544462.5502 41744 -0.0224 119 CCD J. Bialozynski 0.00 24435.6628 51198 -0.0213 105 CCD J. Bialozynski 0.00 54435.6641 51198 -0.0023 53 CCD G. Samolyk 0.00 | п | 50437.559 | 13784 | -0.027 | 13 | CCD | S. Cook n/ | /a |
| u 54498.6820 20432 0.5575 99 CCD J. Bialozynski 0.00 1 54399.8518 13490 -0.0479 94 CCD J. Bialozynski 0.00 1 54339.8518 13490 -0.0479 94 CCD J. Bialozynski 0.00 1 54339.8518 1381.5 -0.0254 81 CCD J. Bialozynski 0.00 1 54421.7588 41624.5 -0.0260 60 CCD J. Bialozynski 0.00 1 54462.5502 41744 -0.0257 91 CCD J. Bialozynski 0.00 1 54462.5502 41744 -0.0224 119 CCD J. Bialozynski 0.00 1 54435.6628 51198 -0.0023 58 CCD J. Bialozynski 0.00 54435.6621 51198 -0.0023 53 CCD G. Samolyk 0.00 54435.66241 51198 -0.0023 53 CCD G. Samolyk 0.00 </td <td>п</td> <td>54447.4029</td> <td>16267</td> <td>0.6660</td> <td>79</td> <td>CCD</td> <td>F. Salvaggio</td> <td>0.0003</td> | п | 54447.4029 | 16267 | 0.6660 | 79 | CCD | F. Salvaggio | 0.0003 |
| 1 54399.8518 13490 -0.0479 94 CCD J. Bialozynski 0.00 1 54338.8117 41381.5 -0.0254 81 CCD J. Bialozynski 0.00 1 54421.7588 41624.5 -0.0256 60 CCD J. Bialozynski 0.00 1 54462.5502 41744 -0.0257 91 CCD G. Samolyk 0.00 1 54462.5502 41744 -0.0257 91 CCD G. Samolyk 0.00 1 54462.5502 41744 -0.0224 119 CCD J. Bialozynski 0.00 1 54435.6628 51198 -0.0213 105 CCD J. Bialozynski 0.00 54435.6628 51198 -0.0023 58 CCD K. Menzies 0.00 54435.6641 51198 -0.0023 53 CCD G. Samolyk 0.00 54380.6403 12226 -0.0701 95 CCD J. Bialozynski 0.00 | п | 54498.6820 | 20432 | 0.5575 | 66 | CCD | J. Bialozynski | 0.0003 |
| 1 54338.8117 41381.5 -0.0254 81 CCD G. Samolyk 0.00 1 54421.7588 41624.5 -0.0260 60 CCD J. Bialozynski 0.00 1 54462.5502 41744 -0.0257 91 CCD J. Bialozynski 0.00 1 54462.5502 41744 -0.0257 91 CCD J. Bialozynski 0.00 1 54462.5502 41744 -0.0224 119 CCD J. Bialozynski 0.00 1 54509.6881 6401 0.02213 105 CCD J. Bialozynski 0.00 54435.6628 51198 -0.0036 28 CCD K. Menzies 0.00 54435.6641 51198 -0.0023 53 CCD G. Samolyk 0.00 54435.6643 12198 -0.0023 53 CCD G. Samolyk 0.00 54436.6473 12226 -0.0701 95 CCD J. Bialozynski 0.00 54448.6473 | _ | 54399.8518 | 13490 | -0.0479 | 94 | CCD | J. Bialozynski | 0.0002 |
| 54421.7588 41624.5 -0.0260 60 CCD J. Bialozynski 0.00 1 54462.5502 41744 -0.0257 91 CCD G. Samolyk 0.00 1 54462.5502 41744 -0.0257 91 CCD J. Bialozynski 0.00 1 54437.7187 6401 0.0224 119 CCD J. Bialozynski 0.00 1 54509.6881 6436 0.0213 105 CCD J. Bialozynski 0.00 54435.6628 51198 -0.0036 28 CCD K. Menzies 0.00 54435.6641 51198 -0.0023 53 CCD G. Samolyk 0.00 54435.6641 51198 -0.0023 53 CCD G. Samolyk 0.00 54435.6641 51198 -0.0701 95 CCD G. Samolyk 0.00 54448.6473 12226 -0.0707 80 CCD J. Bialozynski 0.00 54448.6473 122296 -0.0705 | _ | 54338.8117 | 41381.5 | -0.0254 | 81 | CCD | G. Samolyk | 0.0002 |
| 1 54462.5502 41744 -0.0257 91 CCD G. Samolyk 0.00 1 54437.7187 6401 0.0224 119 CCD J. Bialozynski 0.00 1 54509.6881 6436 0.0213 105 CCD J. Bialozynski 0.00 54550.6881 6436 0.0213 105 CCD J. Bialozynski 0.00 54435.6628 51198 -0.0036 28 CCD K. Menzies 0.00 54435.6641 51198 -0.0023 53 CCD G. Samolyk 0.00 54380.6403 12226 -0.0701 95 CCD G. Samolyk 0.00 54448.6473 12228 -0.0707 80 CCD J. Bialozynski 0.00 54448.6473 12226 -0.0705 71 CCD G. Samolyk 0.00 | _ | 54421.7588 | 41624.5 | -0.0260 | 60 | CCD | J. Bialozynski | 0.0001 |
| 1 54437.7187 6401 0.0224 119 CCD J. Bialozynski 0.00 1 54509.6881 6436 0.0213 105 CCD J. Bialozynski 0.00 54435.6628 51198 -0.0036 28 CCD K. Menzies 0.00 54435.6641 51198 -0.0023 53 CCD G. Samolyk 0.00 54435.6641 51198 -0.0023 53 CCD G. Samolyk 0.00 54435.6641 51198 -0.0701 95 CCD G. Samolyk 0.00 54436.6473 12226 -0.0707 80 CCD J. Bialozynski 0.00 54448.6473 12296 -0.0705 71 CCD G. Samolyk 0.00 | _ | 54462.5502 | 41744 | -0.0257 | 91 | CCD | G. Samolyk | 0.0001 |
| ¹ 54509.6881 6436 0.0213 105 CCD J. Bialozynski 0.00 54435.6628 51198 -0.0036 28 CCD K. Menzies 0.00 54435.6641 51198 -0.0023 53 CCD G. Samolyk 0.00 54380.6403 12226 -0.0701 95 CCD G. Samolyk 0.00 54411.7288 12258 -0.0707 80 CCD J. Bialozynski 0.00 54448.6473 12296 -0.0705 71 CCD G. Samolyk 0.00 | T | 54437.7187 | 6401 | 0.0224 | 119 | CCD | J. Bialozynski | 0.0003 |
| 54435.6628 51198 -0.0036 28 CCD K. Menzies 0.00 54435.6641 51198 -0.0023 53 CCD G. Samolyk 0.00 54435.6641 51198 -0.0723 53 CCD G. Samolyk 0.00 54380.6403 12226 -0.0701 95 CCD G. Samolyk 0.00 54411.7288 12258 -0.0707 80 CCD J. Bialozynski 0.00 54448.6473 12296 -0.0705 71 CCD G. Samolyk 0.00 | 7 | 54509.6881 | 6436 | 0.0213 | 105 | CCD | J. Bialozynski | 0.0005 |
| 54435.6641 51198 -0.0023 53 CCD G. Samolyk 0.00 54380.6403 12226 -0.0701 95 CCD G. Samolyk 0.00 54411.7288 12258 -0.0707 80 CCD J. Bialozynski 0.00 54448.6473 12296 -0.0705 71 CCD G. Samolyk 0.00 | | 54435.6628 | 51198 | -0.0036 | 28 | CCD | K. Menzies | 0.0001 |
| 54380.6403 12226 -0.0701 95 CCD G. Samolyk 0.00 54411.7288 12258 -0.0707 80 CCD J. Bialozynski 0.00 54448.6473 12296 -0.0705 71 CCD G. Samolyk 0.00 | | 54435.6641 | 51198 | -0.0023 | 53 | CCD | G. Samolyk | 0.0001 |
| 54411.7288 12258 –0.0707 80 CCD J. Bialozynski 0.00 54448.6473 12296 –0.0705 71 CCD G. Samolyk 0.00 | | 54380.6403 | 12226 | -0.0701 | 95 | CCD | G. Samolyk | 0.0001 |
| 54448.6473 12296 –0.0705 71 CCD G. Samolyk 0.00 | | 54411.7288 | 12258 | -0.0707 | 80 | CCD | J. Bialozynski | 0.0002 |
| | | 54448.6473 | 12296 | -0.0705 | 71 | CCD | G. Samolyk | 0.0001 |

| | Standard Error | 0.0001 | 0.0001 | 0.0002 | 0.0005 | 0.0002 | 0.0007 | 0.0002 | 0.0003 | 0.0003 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0001 | 0.0002 | 0.0002 | 0.0001 | 0.0002 | 0.0001 | 0 0001 |
|-----------------------|----------------------|----------------|----------------|----------------|------------|------------|------------|----------------|------------|------------|------------|------------|------------|----------------|----------------|------------|----------------|----------------|------------|------------|----------------|------------|
| | Observer | J. Bialozynski | J. Bialozynski | J. Bialozynski | E. Wiley | G. Samolyk | G. Samolyk | J. Bialozynski | K. Menzies | G. Samolyk | K. Menzies | G. Samolyk | G. Samolyk | J. Bialozynski | J. Bialozynski | G. Samolyk | J. Bialozynski | J. Bialozynski | G. Samolyk | G. Samolyk | J. Bialozynski | G Samolvk |
| , cont. | Type | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD |
| rogram | Ν | 55 | 78 | 75 | 34 | 82 | 76 | n/a | 41 | 96 | 33 | 50 | 96 | 60 | 160 | 88 | 78 | 100 | 76 | 108 | 59 | 79 |
| sing binary p | 0-C | -0.0273 | -0.0279 | -0.0265 | -0.0280 | -0.0281 | -0.0537 | -0.0587 | 0.2523 | 0.2538 | 0.0018 | 0.0015 | -0.0937 | -0.0940 | 0.5306 | -0.0115 | -0.0718 | 0.0635 | 0.0599 | 0.0017 | 0.0155 | -0.0001 |
| AAVSO eclips | Cycle | 8616 | 8650 | 11166 | 11223 | 11252 | 25897 | 26253 | 42232.5 | 42277 | 86810 | 86881 | 6811 | 6834 | 5272 | 10038 | 4850 | 9199 | 9206 | 16618 | 36642 | 11759 |
| inima of stars in the | HJD(min) 2400000+ | 54387.7467 | 54452.6495 | 54448.7214 | 54491.6789 | 54513.5351 | 54405.8949 | 54524.6648 | 54505.8002 | 54521.5787 | 54505.8560 | 54519.8194 | 54493.5538 | 54521.6669 | 54514.7606 | 54380.6128 | 54385.6722 | 54388.6973 | 54399.5580 | 54366.6433 | 54382.7400 | 54338,6624 |
| Times of mi | Star | RS Tri | RS Tri | RV Tri | RV Tri | RV Tri | W UMa | W UMa | TY UMa | TY UMa | UX UMa | UX UMa | XZ UMa | XZ UMa | AF UMa | AW Vul | AY Vul | BE Vul | BE Vul | BT Vul | BU Vul | CD Vul |

Recent Minima of 184 Eclipsing Binary Stars

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Received October 18, 2008; revised October 23, 2008; accepted October 30, 2008

Abstract This paper continues the publication of times of minima for eclipsing binary stars from observations reported to the AAVSO Eclipsing Binary Committee. Times of minima from observations made from March 2008 through August 2008 are presented.

1. Recent Observations

The accompanying list contains times of minima calculated from recent CCD observations made by participants in the AAVSO's eclipsing binary program. This list will be web-archived and made available through the AAVSO ftp site at ftp://ftp.aavso.org/public/datasets/jsamo2j362.txt. This list, along with eclipsing binary data from earlier AAVSO publications, is also included in the Lichtenknecker database administrated by the Bundesdeutsche Arbeitsgemeinschaft für Veränderliche Sterne e.V. (BAV) at http://www.bav-astro.de/LkDB/index.php?lang=en. These observations were reduced by the observers or the writer using the method of Kwee and Van Worden (1956). The standard error is included when available.

The linear elements in the *General Catalog of Variable Stars* (GCVS; Kholopov *et al.* 1985) were used to compute the O–C values for most stars. For a few exceptions where the GCVS elements are missing or are in significant error, light elements from another source are used: CD Cam (Baldwin and Samolyk 2007), CW Cas (Samolyk 1992a), DV Cep (Frank and Lichtenknecker 1987), Z Dra (Danielkiewicz-Krośniak and Kurpińska-Winiarska 1996), DF Hya (Samolyk 1992b), DK Hya (Samolyk 1990), EF Ori (Baldwin and Samolyk 2005), GU Ori (Samolyk 1985). O–C values listed in this paper can be directly compared with values published in recent numbers of the AAVSO *Observed Minima Timingsof Eclipsing Binaries* series.

The number of observations used for determination of each time of minimum is given under N in the table when available.

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| Table 1. Times of r | ninima of stars in th | e AAVSO eclip | osing binary J | program | ÷ | | |
|---------------------|-----------------------|---------------|----------------|---------|------|----------------|-------------------|
| Star | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error |
| RT And | 54641.8533 | 21465 | -0.0077 | 70 | CCD | G. Samolyk | 0.0001 |
| RT And | 54653.8019 | 21484 | -0.0088 | 65 | CCD | G. Samolyk | 0.0001 |
| RT And | 54709.7774 | 21573 | -0.0080 | 74 | CCD | G. Samolyk | 0.0001 |
| WZ And | 54702.7051 | 19881 | 0.0464 | 106 | CCD | G. Samolyk | 0.0002 |
| XZ And | 54708.8488 | 22642 | 0.1688 | 74 | CCD | G. Samolyk | 0.0001 |
| AB And | 54674.7747 | 55937.5 | -0.0217 | 65 | CCD | G. Samolyk | 0.0001 |
| AB And | 54676.7659 | 55943.5 | -0.0219 | 81 | CCD | K. Menzies | 0.0001 |
| AB And | 54701.8228 | 56019 | -0.0228 | 41 | CCD | K. Menzies | 0.0001 |
| AD And | 54688.8274 | 15906 | -0.0546 | 78 | CCD | G. Samolyk | 0.0002 |
| BD And | 54596.8802 | 42416 | 0.0162 | 52 | CCD | G. Samolyk | 0.0002 |
| BD And | 54680.6656 | 42597 | 0.0163 | 75 | CCD | G. Samolyk | 0.0003 |
| BX And | 54652.8182 | 29706 | -0.0458 | 72 | CCD | G. Samolyk | 0.0003 |
| BX And | 54710.7780 | 29801 | -0.0469 | 87 | CCD | G. Samolyk | 0.0003 |
| DS And | 54710.6894 | 18375 | 0.0018 | 117 | CCD | G. Samolyk | 0.0004 |
| RY Aqr | 54688.8141 | 7050 | -0.0876 | 84 | CCD | G. Samolyk | 0.0001 |
| CX Aqr | 54688.7983 | 32798 | 0.0079 | 65 | CCD | G. Samolyk | 0.0001 |
| CZ Aqr | 54702.8390 | 13134 | -0.0410 | 71 | CCD | G. Samolyk | 0.0001 |
| XZ Aql | 54631.7393 | 5950 | 0.1514 | 06 | CCD | G. Samolyk | 0.0003 |
| KP Aql | 54630.8161 | 4227 | -0.0113 | 80 | CCD | J. Bialozynski | 0.0002 |
| 00 Aql | 54596.8635 | 31539 | 0.0394 | 80 | CCD | G. Samolyk | 0.0001 |

| Star | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error |
|----------|----------------------|---------|---------|-----|------|----------------|-------------------|
| 00 Aql | 54639.6886 | 31623.5 | 0.0409 | 80 | CCD | K. Menzies | 0.0002 |
| 00 Aql | 54668.8275 | 31681 | 0.0395 | 50 | CCD | R. Sabo | 0.0003 |
| 00 Aql | 54681.7517 | 31706.5 | 0.0406 | 62 | CCD | G. Samolyk | 0.0003 |
| V343 Aql | 54660.7082 | 14213 | -0.0512 | 90 | CCD | G. Samolyk | 0.0001 |
| V346 Aql | 54653.7185 | 11511 | -0.0100 | 96 | CCD | G. Samolyk | 0.0001 |
| SS Air | 54681.8308 | 38556.5 | -0.2564 | 70 | CCD | G. Samolyk | 0.0004 |
| SX Aur | 54535.6795 | 11878 | 0.0114 | 80 | CCD | J. Bialozynski | 0.0003 |
| WW Aur | 54554.6564 | 8558 | 0.0026 | 64 | CCD | G. Samolyk | 0.0004 |
| AP Aur | 54527.5996 | 21223.5 | 1.1868 | 45 | CCD | K. Menzies | 0.0002 |
| AP Aur | 54540.6960 | 21246.5 | 1.1890 | 80 | CCD | J. Bialozynski | 0.0002 |
| AP Aur | 54562.6155 | 21285 | 1.1899 | 79 | CCD | G. Samolyk | 0.0003 |
| CL Aur | 54554.6225 | 17348 | 0.1252 | 63 | CCD | G. Samolyk | 0.0002 |
| EP Aur | 54537.7096 | 47763 | 0.0125 | 60 | CCD | J. Bialozynski | 0.0002 |
| SS Boo | 54212.4147 | 4406 | 5.6417 | 170 | CCD | J. Bialozynski | 0.0003 |
| SS Boo | 54592.6845 | 4456 | 5.7549 | 158 | CCD | S. Diesso | 0.0007 |
| TU Boo | 54556.7644 | 66270 | -0.1258 | 60 | CCD | J. Bialozynski | 0.0001 |
| TU Boo | 54562.7650 | 66288.5 | -0.1245 | 63 | CCD | G. Samolyk | 0.0002 |
| TU Boo | 54563.7380 | 66291.5 | -0.1244 | 64 | CCD | J. Bialozynski | 0.0003 |
| TU Boo | 54583.6791 | 66353 | -0.1269 | 102 | CCD | G. Samolyk | 0.0002 |
| TV BOO | 1032 2213 | 02623 | 0000 | 4 | | | 0,0002 |

| Table 1. Times of n | ninima of stars in th | e AAVSO eclip | sing binary J | program | ı, cont. | | | |
|---------------------|-----------------------|---------------|---------------|---------|----------|----------------|-------------------|---|
| Star | HJD(min) 2400000+ | Cycle | 0-C | N | Type | Observer | Standard Error | |
| TY Boo | 54556.7534 | 63302.5 | 0.0861 | 09 | CCD | J. Bialozynski | 0.0004 | 1 |
| TY Boo | 54579.7451 | 63375 | 0.0846 | 59 | CCD | J. Bialozynski | 0.0001 | |
| TY Boo | 54583.7102 | 63387.5 | 0.0854 | 92 | CCD | G. Samolyk | 0.0001 | |
| TY Boo | 54592.7481 | 63416 | 0.0846 | 68 | CCD | K. Menzies | 0.0001 | |
| TY Boo | 54611.6206 | 63475.5 | 0.0868 | 26 | CCD | R. Crumrine | 0.0005 | |
| TY Boo | 54615.7429 | 63488.5 | 0.0861 | 53 | CCD | K. Menzies | 0.0001 | |
| TYB00 | 54616.6945 | 63491.5 | 0.0863 | 60 | CCD | K. Menzies | 0.0002 | |
| TY Boo | 54643.6522 | 63576.5 | 0.0865 | 55 | CCD | K. Menzies | 0.0003 | |
| TZ Boo | 54540.7879 | 50167.5 | 0.0715 | 89 | CCD | G. Samolyk | 0.0001 | |
| TZ Boo | 54561.7378 | 50238 | 0.0714 | 62 | CCD | J. Bialozynski | 0.0005 | |
| TZ Boo | 54568.7231 | 50261.5 | 0.0734 | 60 | CCD | J. Bialozynski | 0.0002 | |
| TZ Boo | 54575.7043 | 50285 | 0.0713 | 69 | CCD | K. Menzies | 0.0002 | |
| TZ Boo | 54615.6752 | 50419.5 | 0.0739 | 69 | CCD | K. Menzies | 0.0001 | |
| TZ Boo | 54619.6842 | 50433 | 0.0713 | LL | CCD | K. Menzies | 0.0002 | |
| UW Boo | 54554.6720 | 12093 | -0.0087 | 70 | CCD | G. Samolyk | 0.0004 | |
| UW Boo | 54561.7068 | 12100 | -0.0069 | 65 | CCD | J. Bialozynski | 0.0002 | |
| VW Boo | 54560.7435 | 68319.5 | -0.1558 | 59 | CCD | J. Bialozynski | 0.0002 | |
| VW Boo | 54565.7080 | 68334 | -0.1551 | 60 | CCD | J. Bialozynski | 0.0004 | |
| VW Boo | 54612.6061 | 68471 | -0.1555 | 91 | CCD | K. Menzies | 0.0002 | |
| AD Boo | 54580.6816 | 12709 | 0.0262 | 124 | CCD | G. Samolyk | 0.0005 | |

| Star | HJD(min) | Cycle | 0-C | Ν | Type | Observer | Standard |
|--------|------------|--------|---------|-----|------|----------------|----------|
| | 2400000 + | | | | | | Error |
| AD Boo | 54580.6830 | 12709 | 0.0276 | 74 | CCD | J. Bialozynski | 0.0002 |
| AD Boo | 54581.7177 | 12710 | 0.0279 | 80 | CCD | J. Bialozynski | 0.0003 |
| Y Cam | 54561.6996 | 3509 | 0.3360 | 143 | CCD | G. Samolyk | 0.0001 |
| Y Cam | 54670.7915 | 3542 | 0.3423 | 147 | CCD | G. Samolyk | 0.0003 |
| SV Cam | 54562.8172 | 20180 | 0.0504 | 85 | CCD | G. Samolyk | 0.0002 |
| SV Cam | 54657.7097 | 20340 | 0.0517 | 65 | CCD | G. Samolyk | 0.0005 |
| SV Cam | 54696.8518 | 20406 | 0.0512 | 98 | CCD | G. Samolyk | 0.0002 |
| AL Cam | 54610.6785 | 21229 | -0.0332 | 91 | CCD | G. Samolyk | 0.0001 |
| CD Cam | 54554.7151 | 2345 | 0.0046 | 100 | CCD | J. Bialozynski | 0.0005 |
| CD Cam | 54559.6809 | 2351.5 | 0.0032 | 90 | CCD | J. Bialozynski | 0.0009 |
| R CMa | 54535.6289 | 9020 | 0.0846 | 70 | CCD | J. Bialozynski | 0.0007 |
| RT CMa | 54540.5867 | 21577 | -0.6787 | 79 | CCD | G. Samolyk | 0.0002 |
| SX CMa | 54554.6019 | 16290 | 0.0329 | 62 | CCD | G. Samolyk | 0.0004 |
| TZ CMa | 54538.6765 | 14342 | -0.1530 | 80 | CCD | J. Bialozynski | 0.0004 |
| XZ CMi | 54534.5671 | 20888 | -0.0074 | 78 | CCD | G. Samolyk | 0.0002 |
| AK CMi | 54561.6455 | 20251 | -0.0168 | 103 | CCD | G. Samolyk | 0.0003 |
| RW Cap | 53268.9041 | 3126 | -0.4141 | 118 | CCD | G. Samolyk | 0.0003 |
| RW Cap | 53672.5688 | 3245 | -0.4505 | 82 | CCD | G. Samolyk | 0.0002 |
| RW Cap | 54296.7400 | 3429 | -0.4893 | 95 | CCD | G. Samolyk | 0.0003 |
| TV Can | 51680 7073 | 6016 | 0.0620 | 90 | | C. Somolarla | 0,000 |

| Table 1. Times of m | inima of stars in the | e AAVSO eclip | sing binary J | program | ı, cont. | | |
|---------------------|-----------------------|---------------|---------------|---------|----------|----------------|-------------------|
| Star | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error |
| TV Cas | 54705.8385 | 5574 | -0.0228 | 147 | CCD | G. Samolyk | 0.0003 |
| AB Cas | 54562.6194 | 8668 | 0.0946 | 78 | CCD | G. Samolyk | 0.0001 |
| AB Cas | 54652.8344 | 8734 | 0.0959 | 73 | CCD | G. Samolyk | 0.0003 |
| AB Cas | 54708.8772 | 8775 | 0.0969 | 93 | CCD | G. Samolyk | 0.0001 |
| CW Cas | 54660.7675 | 40859.5 | -0.0452 | 87 | CCD | G. Samolyk | 0.0002 |
| CW Cas | 54681.8114 | 40925.5 | -0.0463 | 57 | CCD | G. Samolyk | 0.0003 |
| CW Cas | 54705.7267 | 41000.5 | -0.0458 | 102 | CCD | K. Menzies | 0.0001 |
| DZ Cas | 54653.6849 | 33405 | -0.1750 | 81 | CCD | G. Samolyk | 0.0006 |
| IR Cas | 54653.8386 | 18055 | 0.0097 | 72 | CCD | G. Samolyk | 0.0001 |
| MM Cas | 54680.8302 | 16642 | 0.0895 | 88 | CCD | G. Samolyk | 0.0002 |
| MM Cas | 54694.7319 | 16654 | 0.0895 | 146 | CCD | C. Hesseltine | 0.0002 |
| OR Cas | 54681.8187 | 8406 | -0.0220 | 63 | CCD | G. Samolyk | 0.0002 |
| PV Cas | 54710.7589 | 8274 | -0.0331 | 89 | CCD | G. Samolyk | 0.0002 |
| V364 Cas | 54674.7716 | 13182.5 | -0.0203 | 85 | CCD | G. Samolyk | 0.0008 |
| V375 Cas | 54696.6222 | 13611 | 0.1334 | 45 | CCD | G. Samolyk | 0.0007 |
| V380 Cas | 54674.7954 | 21388 | -0.0645 | 87 | CCD | G. Samolyk | 0.0004 |
| SU Cep | 54616.8451 | 31386 | 0.0052 | 80 | CCD | J. Bialozynski | 0.0001 |
| SU Cep | 54653.8024 | 31427 | 0.0050 | 80 | CCD | G. Samolyk | 0.0001 |
| SU Cep | 54700.6754 | 31479 | 0.0052 | 40 | CCD | K. Menzies | 0.0004 |
| WZ Cep | 54583.8498 | 63585 | -0.0801 | 63 | CCD | G. Samolyk | 0.0003 |

| Star | HJD(min) | Cvcle | 0-C | Ν | Type | Observer | Standard |
|---------|------------|---------|---------|-----|------|----------------|----------|
| | 2400000 + | 2 | | | | | Error |
| WZ Cep | 54628.7261 | 63692.5 | -0.0793 | 60 | CCD | J. Bialozynski | 0.0007 |
| WZ Cep | 54635.8208 | 63709.5 | -0.0812 | 60 | CCD | J. Bialozynski | 0.0003 |
| WZ Cep | 54651.6853 | 63747.5 | -0.0797 | 78 | CCD | G. Samolyk | 0.0003 |
| WZ Cep | 54702.8179 | 63870 | -0.0844 | 84 | CCD | G. Samolyk | 0.0002 |
| XX Cep | 54623.8303 | 4186 | -0.0210 | 80 | CCD | J. Bialozynski | 0.0002 |
| XX Cep | 54705.6379 | 4221 | -0.0199 | LL | CCD | G. Samolyk | 0.0001 |
| ZZ Cep | 54623.8311 | 12464 | -0.0151 | 100 | CCD | J. Bialozynski | 0.0007 |
| DK Cep | 54631.8095 | 21342 | 0.0321 | 70 | CCD | G. Samolyk | 0.0002 |
| DK Cep | 54635.7535 | 21346 | 0.0325 | 90 | CCD | J. Bialozynski | 0.0002 |
| DL Cep | 54596.7026 | 12665 | 0.0527 | 125 | CCD | G. Samolyk | 0.0003 |
| DL Cep | 54622.7902 | 12681 | 0.0526 | 100 | CCD | J. Bialozynski | 0.0004 |
| DL Cep | 54702.6836 | 12730 | 0.0525 | 95 | CCD | G. Samolyk | 0.0003 |
| DV Cep | 54607.8409 | 6751 | -0.0040 | 80 | CCD | J. Bialozynski | 0.0001 |
| DV Cep | 54649.6718 | 6787 | -0.0042 | 100 | CCD | G. Samolyk | 0.0002 |
| DV Cep | 54700.7995 | 6831 | -0.0034 | LL | CCD | K. Menzies | 0.0003 |
| EG Cep | 54632.7176 | 22104 | 0.0142 | 100 | CCD | G. Samolyk | 0.0001 |
| EK Cep | 54632.8419 | 3530 | 0.0100 | 107 | CCD | J. Bialozynski | 0.0002 |
| EK Cep | 54641.6975 | 3532 | 0.0100 | 82 | CCD | G. Samolyk | 0.0002 |
| TT Cet | 54708.7894 | 45607 | -0.0587 | 96 | CCD | G. Samolyk | 0.0002 |
| TW/ Cat | JUZO LULVZ | 20017 5 | 02000 | 70 | | C Comolaile | |

| Table 1. Times of | minima of stars in th | e AAVSO eclip | sing binary] | program | ı, cont. | | | |
|-------------------|-----------------------|---------------|---------------|---------|----------|----------------|-------------------|---|
| Star | HJD(min) 2400000+ | Cycle | 0-C | N | Type | Observer | Standard Error | 1 |
| RW Com | 54570.7514 | 61296 | -0.0192 | 60 | CCD | J. Bialozynski | 0.0001 | 1 |
| RW Com | 54573.5995 | 61308 | -0.0192 | 75 | CCD | K. Menzies | 0.0001 | |
| RW Com | 54597.6892 | 61409.5 | -0.0201 | 35 | CCD | K. Menzies | 0.0001 | |
| RW Com | 54620.7115 | 61506.5 | -0.0204 | 60 | CCD | J. Bialozynski | 0.0002 | |
| RZ Com | 54527.6806 | 58168 | 0.0415 | 47 | CCD | K. Menzies | 0.0001 | |
| RZ Com | 54540.7133 | 58206.5 | 0.0417 | 83 | CCD | G. Samolyk | 0.0002 | |
| RZ Com | 54555.7770 | 58251 | 0.0419 | 59 | CCD | J. Bialozynski | 0.0001 | |
| RZ Com | 54580.6577 | 58324.5 | 0.0424 | 55 | CCD | J. Bialozynski | 0.0002 | |
| RZ Com | 54628.7257 | 58466.5 | 0.0425 | 60 | CCD | J. Bialozynski | 0.0002 | |
| SS Com | 54555.7638 | 71592 | 0.6561 | 80 | CCD | J. Bialozynski | 0.0004 | |
| SS Com | 54561.7491 | 71606.5 | 0.6559 | 76 | CCD | G. Samolyk | 0.0003 | |
| SS Com | 54566.7022 | 71618.5 | 0.6555 | 74 | CCD | J. Bialozynski | 0.0004 | |
| SS Com | 54576.6105 | 71642.5 | 0.6568 | 73 | CCD | K. Menzies | 0.0006 | |
| SS Com | 54610.6679 | 71725 | 0.6589 | LL | CCD | G. Samolyk | 0.0004 | |
| CC Com | 54534.6056 | 67974.5 | -0.0169 | 55 | CCD | G. Samolyk | 0.0002 | |
| CC Com | 54615.5974 | 68341.5 | -0.0170 | 39 | CCD | K. Menzies | 0.0001 | |
| U CrB | 54573.8567 | 10957 | 0.1149 | 100 | CCD | J. Bialozynski | 0.0003 | |
| U CrB | 54580.7619 | 10959 | 0.1157 | 115 | CCD | G. Samolyk | 0.0004 | |
| RW CrB | 54573.8819 | 19028 | -0.0044 | 80 | CCD | J. Bialozynski | 0.0002 | |
| RW CrB | 54624.7302 | 19098 | -0.0049 | 71 | CCD | G. Samolyk | 0.0003 | |

| Table 1. Times of m | iinima of stars in the | e AAVSO eclip | sing binary p | orogram | ı, cont. | | |
|---------------------|------------------------|---------------|---------------|---------|----------|----------------|-------------------|
| Star | HJD(min) 2400000+ | Cycle | 0-C | N | Type | Observer | Standard Error |
| RW CrB | 54680.6646 | 19175 | -0.0042 | 94 | CCD | G. Samolyk | 0.0002 |
| W Crv | 54540.7717 | 38376 | 0.0158 | 80 | CCD | G. Samolyk | 0.0001 |
| W Crv | 54554.7430 | 38412 | 0.0162 | 92 | CCD | G. Samolyk | 0.0002 |
| W Crv | 54567.7469 | 38445.5 | 0.0194 | 79 | CCD | J. Bialozynski | 0.0002 |
| W Crv | 54569.6873 | 38450.5 | 0.0193 | 75 | CCD | J. Bialozynski | 0.0002 |
| RV Crv | 54561.6827 | 18109.5 | -0.0632 | 103 | CCD | G. Samolyk | 0.0007 |
| RV Crv | 54571.7654 | 18123 | -0.0684 | 75 | CCD | J. Bialozynski | 0.0002 |
| RV Crv | 54611.7413 | 18176.5 | -0.0705 | 78 | CCD | J. Bialozynski | 0.0007 |
| V Crt | 54557.6985 | 18746 | -0.0025 | 80 | CCD | J. Bialozynski | 0.0001 |
| V Crt | 54583.6744 | 18783 | -0.0020 | 87 | CCD | G. Samolyk | 0.0003 |
| Y Cyg | 54648.6687 | 15083.5 | 0.0637 | 91 | CCD | G. Samolyk | 0.0006 |
| Y Cyg | 54651.6665 | 15084.5 | 0.0652 | 62 | CCD | G. Samolyk | 0.0005 |
| WW Cyg | 54617.8251 | 4292 | 0.0746 | 95 | CCD | J. Bialozynski | 0.0001 |
| WW Cyg | 54637.7322 | 4298 | 0.0750 | 90 | CCD | K. Menzies | 0.0001 |
| WW Cyg | 54710.7234 | 4320 | 0.0753 | 94 | CCD | G. Samolyk | 0.0001 |
| ZZ Cyg | 54618.7645 | 15301 | -0.0526 | 80 | CCD | K. Menzies | 0.0001 |
| ZZ Cyg | 54618.7646 | 15301 | -0.0525 | 80 | CCD | J. Bialozynski | 0.0001 |
| ZZ Cyg | 54652.7093 | 15355 | -0.0531 | 71 | CCD | G. Samolyk | 0.0002 |
| AE Cyg | 54635.7264 | 10369 | -0.0045 | 60 | CCD | K. Menzies | 0.0002 |
| CG Cyg | 54621.7967 | 24078 | 0.0616 | 60 | CCD | J. Bialozynski | 0.0002 |

| Times of m | inima of stars in th | e AAVSO ecli | psing binary l | program | ı, cont. | | | |
|------------|----------------------|--------------|----------------|---------|----------|----------------|-------------------|--|
| Star | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error | |
| CG Cyg | 54638.8373 | 24105 | 0.0614 | 77 | CCD | E. Wiley | 0.0002 | |
| CG Cyg | 54676.7052 | 24165 | 0.0608 | 25 | CCD | K. Menzies | 0.0006 | |
| DK Cyg | 54642.8110 | 35359 | 0.0800 | 93 | CCD | K. Menzies | 0.0003 | |
| DK Cyg | 54643.7535 | 35361 | 0.0812 | 76 | CCD | K. Menzies | 0.0006 | |
| DK Cyg | 54652.6944 | 35380 | 0.0789 | 72 | CCD | G. Samolyk | 0.0002 | |
| DK Cyg | 54681.8799 | 35442 | 0.0816 | 50 | CCD | G. Samolyk | 0.0006 | |
| KR Cyg | 54614.7946 | 30182 | 0.0130 | 80 | CCD | J. Bialozynski | 0.0002 | |
| KR Cyg | 54653.6721 | 30228 | 0.0135 | 79 | CCD | G. Samolyk | 0.0002 | |
| KR Cyg | 54702.6904 | 30286 | 0.0130 | 106 | CCD | K. Menzies | 0.0001 | |
| KV Cyg | 54641.7976 | 8867 | 0.0523 | 98 | CCD | J. Bialozynski | 0.0003 | |
| MY Cyg | 54698.6114 | 5206 | -0.0007 | 262 | CCD | K. Menzies | 0.0002 | |
| MY Cyg | 54702.6188 | 5207 | 0.0015 | 90 | CCD | G. Samolyk | 0.0003 | |
| V387 Cyg | 54613.7906 | 41568 | 0.0184 | 60 | CCD | J. Bialozynski | 0.0001 | |
| V387 Cyg | 54674.6474 | 41663 | 0.0186 | 72 | CCD | G. Samolyk | 0.0003 | |
| V387 Cyg | 54681.6931 | 41674 | 0.0177 | 80 | CCD | G. Samolyk | 0.0002 | |
| V388 Cyg | 54619.7630 | 14745 | -0.0778 | 90 | CCD | K. Menzies | 0.0002 | |
| V388 Cyg | 54619.7671 | 14745 | -0.0737 | 50 | CCD | J. Bialozynski | 0.001 | |
| V388 Cyg | 54649.8306 | 14780 | -0.0765 | 94 | CCD | G. Samolyk | 0.0002 | |
| V388 Cyg | 54650.6872 | 14781 | -0.0790 | 95 | CCD | K. Menzies | 0.0001 | |
| V401 Cyg | 54612.7643 | 18495 | 0.0619 | 78 | CCD | J. Bialozynski | 0.0004 | |

| Table 1. Times of m | inima of stars in th | e AAVSO eclip | sing binary J | orogram | ı, cont. | | | |
|---------------------|----------------------|---------------|---------------|---------|----------|----------------|-------------------|--|
| Star | HJD(min) 2400000+ | Cycle | 0-C | N | Type | Observer | Standard Error | |
| V401 Cyg | 54703.6687 | 18651 | 0.0617 | 61 | CCD | K. Menzies | 0.0003 | |
| V456 Cyg | 54613.8058 | 10887 | 0.0433 | 60 | CCD | J. Bialozynski | 0.0002 | |
| V466 Cyg | 54617.8683 | 18571.5 | 0.0059 | 75 | CCD | J. Bialozynski | 0.0001 | |
| V466 Cyg | 54631.7834 | 18581.5 | 0.0054 | 80 | CCD | J. Bialozynski | 0.0002 | |
| V466 Cyg | 54688.8375 | 18622.5 | 0.0053 | 70 | CCD | G. Samolyk | 0.0001 | |
| V477 Cyg | 54703.7643 | 4480 | -0.0175 | 26 | CCD | R. Sabo | 0.0001 | |
| V548 Cyg | 54612.7561 | 5626 | 0.0194 | 75 | CCD | J. Bialozynski | 0.0003 | |
| V704 Cyg | 54630.8199 | 29247 | 0.0310 | 24 | CCD | K. Menzies | 0.0003 | |
| V704 Cyg | 54630.8203 | 29247 | 0.0314 | 80 | CCD | J. Bialozynski | 0.0004 | |
| V704 Cyg | 54701.5877 | 29371 | 0.0315 | 70 | CCD | K. Menzies | 0.0002 | |
| V704 Cyg | 54705.5820 | 29378 | 0.0309 | LL | CCD | K. Menzies | 0.0001 | |
| V1034 Cyg | 54611.8027 | 11949 | -0.0048 | 61 | CCD | K. Menzies | 0.0004 | |
| V1034 Cyg | 54702.6566 | 12042 | -0.0055 | 112 | CCD | G. Samolyk | 0.0003 | |
| W Del | 54651.7480 | 2356 | 0.0269 | 118 | CCD | G. Samolyk | 0.0002 | |
| TY Del | 54652.7909 | 9817 | 0.0532 | 73 | CCD | G. Samolyk | 0.0002 | |
| YY Del | 54610.8408 | 14691 | 0.0113 | 67 | CCD | G. Samolyk | 0.0002 | |
| YY Del | 54637.8058 | 14725 | 0.0112 | 80 | CCD | J. Bialozynski | 0.0001 | |
| Z Dra | 54615.7556 | 3515 | -0.0319 | 80 | CCD | J. Bialozynski | 0.0001 | |
| RZ Dra | 54606.7443 | 18932 | 0.0460 | 60 | CCD | J. Bialozynski | 0.0001 | |
| RZ Dra | 54660.7287 | 19030 | 0.0448 | 102 | CCD | G. Samolyk | 0.0002 | |

| (In the A stars in the A HJD(min) | Cvcle | 0-C | 2 | Tvpe | Observer | Standard |
|-----------------------------------|--------|---------|-----|------|----------------|----------|
| (1)00 +000 | Cycle | 5 | Å7 | adir | 00061 461 | Error |
| 7581 | 19119 | 0.0464 | 72 | CCD | G. Samolyk | 0.0002 |
| 107 | 3736 | 0.0353 | 90 | CCD | J. Bialozynski | 0.0002 |
| 442 | 3741 | 0.0346 | 154 | CCD | G. Samolyk | 0.0001 |
| 530 | 3757 | 0.0338 | 105 | CCD | G. Samolyk | 0.0002 |
| 200 | 3995.5 | 0.0033 | 42 | CCD | K. Menzies | 0.0004 |
| 542 | 3999.5 | 0.0023 | 98 | CCD | K. Menzies | 0.0002 |
| 594 | 4001 | 0.0055 | 100 | CCD | J. Bialozynski | 0.0001 |
| 92 | 8038 | -0.0026 | 100 | CCD | J. Bialozynski | 0.0003 |
| 98 | 12061 | 0.0001 | 98 | CCD | J. Bialozynski | 0.0007 |
| 30 | 12093 | -0.0010 | 132 | CCD | G. Samolyk | 0.0003 |
| 26 | 12107 | -0.0014 | 209 | CCD | K. Menzies | 0.0001 |
| 69 | 15522 | -0.0198 | 99 | CCD | G. Samolyk | 0.0001 |
| 14 | 15535 | -0.0205 | | CCD | J. Virtanen | 0.0001 |
| 40 | 15555 | -0.0199 | 79 | CCD | J. Bialozynski | 0.0001 |
| 16 | 15588 | -0.0196 | 57 | CCD | E. Wiley | 0.0001 |
| 161 | 16004 | 0.0354 | 80 | CCD | J. Bialozynski | 0.0003 |
| 334 | 16131 | 0.0362 | 81 | CCD | G. Samolyk | 0.0001 |
| 704 | 4661 | -0.1809 | 100 | CCD | J. Bialozynski | 0.0001 |
| 066 | 4672 | -0.1817 | 125 | CCD | G. Samolyk | 0.0001 |
| 92 | 4694 | -0.1831 | 35 | CCD | K. Menzies | 0.0002 |

| Table 1. Times of n | ninima of stars in th | e AAVSO eclip | sing binary] | program | l, cont. | | |
|---------------------|-----------------------|---------------|---------------|---------|----------|----------------|-------------------|
| Star | HJD(min) 2400000+ | Cycle | 0-C | N | Type | Observer | Standard Error |
| UX Her | 54615.7325 | 9648 | 0.0694 | 95 | CCD | J. Bialozynski | 0.0002 |
| UX Her | 54629.6719 | 9657 | 0.0692 | 105 | CCD | K. Menzies | 0.0001 |
| UX Her | 54663.7475 | 9679 | 0.0701 | 134 | CCD | G. Samolyk | 0.0001 |
| CC Her | 54627.7862 | 8627 | 0.1762 | 80 | CCD | J. Bialozynski | 0.0001 |
| CC Her | 54653.7968 | 8642 | 0.1767 | 56 | CCD | G. Samolyk | 0.0002 |
| CT Her | 54607.7618 | 6765 | 0.0043 | 79 | CCD | J. Bialozynski | 0.0003 |
| CT Her | 54641.7016 | 6784 | 0.0030 | 130 | CCD | G. Samolyk | 0.0002 |
| WY Hya | 54527.7585 | 19492.5 | 0.0263 | 60 | CCD | J. Bialozynski | 0.0001 |
| WY Hya | 54532.7702 | 19499.5 | 0.0260 | 60 | CCD | J. Bialozynski | 0.0002 |
| WY Hya | 54540.6464 | 19510.5 | 0.0261 | 65 | CCD | R. Poklar | 0.0002 |
| AV Hya | 54530.6917 | 26130 | -0.0883 | 72 | CCD | J. Bialozynski | 0.0005 |
| DF Hya | 54532.6783 | 35525.5 | -0.0141 | 75 | CCD | R. Poklar | 0.0001 |
| DF Hya | 54545.5721 | 35564.5 | -0.0139 | 99 | CCD | G. Samolyk | 0.0001 |
| DF Hya | 54552.6809 | 35586 | -0.0131 | 79 | CCD | J. Bialozynski | 0.0001 |
| DF Hya | 54566.7304 | 35628.5 | -0.0144 | LL | CCD | J. Bialozynski | 0.0005 |
| DI Hya | 54531.6923 | 37965 | -0.0253 | 79 | CCD | J. Bialozynski | 0.0001 |
| DK Hya | 54533.7043 | 22398 | 0.0065 | 98 | CCD | G. Samolyk | 0.0002 |
| DK Hya | 54544.6642 | 22419 | 0.0060 | 73 | CCD | R. Poklar | 0.0002 |
| DK Hya | 54544.6648 | 22419 | 0.0066 | 75 | CCD | J. Bialozynski | 0.0002 |
| SW Lac | 54639.8156 | 29198.5 | -0.1013 | 118 | CCD | K. Menzies | 0.0003 |

| | andard Error | .0002 | .0001 | .0002 | .0001 | .0002 | .0006 | .0004 | .0001 | .0003 | .0001 | .0003 | .0002 | .0003 | .0002 | .0002 | .0002 | .0002 | .0005 | .0002 | .0004 |
|-----------------------|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|----------------|------------|------------|----------------|------------|------------|------------|----------------|------------|
| | Si | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Observer | G. Samolyk | K. Menzies | G. Samolyk | K. Menzies | G. Samolyk | J. Bialozynski | G. Samolyk | H. Gerner | J. Bialozynski | G. Samolyk | G. Samolyk | G. Samolyk | J. Bialozynski | G. Samolyk |
| , cont. | Type | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD |
| program | Ν | 80 | 144 | 51 | 06 | 85 | 06 | 68 | 57 | 73 | 94 | 51 | 80 | 89 | 88 | 105 | 88 | 75 | 100 | 108 | 78 |
| osing binary | 0-C | -0.1012 | -0.1015 | 0.0646 | 0.0650 | -0.0034 | 0.0051 | -0.2165 | -0.0149 | 0.1557 | 0.0311 | 0.0308 | -0.0665 | -0.0694 | -0.1020 | -0.0991 | -0.0993 | -0.1684 | 0.1196 | 0.1194 | -0.0271 |
| in the AAVSO eclip | Cycle | 29313.5 | 29398 | 8770 | 8794 | 17216 | 17602.5 | 4607 | 5396 | 5439 | 26901 | 26981 | 21438 | 21494 | 3035 | 3039 | 3042 | 27293 | 9338 | 9347 | 5767 |
| ninima of stars in th | HJD(min) 2400000+ | 54676.6986 | 54703.7992 | 54681.8447 | 54707.6330 | 54652.6832 | 54680.7854 | 54674.6726 | 54534.6425 | 54533.7225 | 54583.6381 | 54631.6446 | 54529.6543 | 54590.6862 | 54562.6170 | 54574.6994 | 54583.7589 | 54545.6061 | 54583.8077 | 54596.7495 | 54596.8841 |
| Table 1. Times of r | Star | SW Lac | SW Lac | VX Lac | VX Lac | CM Lac | CO Lac | DG Lac | Y Leo | UU Leo | UV Leo | UV Leo | VZ Leo | VZ Leo | T LMi | T LMi | T LMi | Z Lep | SS Lib | SS Lib | UZ Lyr |

| Table 1. Times of mi | inima of stars in th | e AAVSO eclip | sing binary l | program | I, cont. | | |
|----------------------|----------------------|---------------|---------------|---------|----------|-----------------------|-------------------|
| Star | HJD(min) 2400000+ | Cycle | 0-C | N | Type | Observer ⁻ | Standard Error |
| UZ Lyr | 54632.8188 | 5786 | -0.0265 | 66 | CCD | J. Bialozynski | 0.0002 |
| EW Lyr | 54590.7758 | 14415 | 0.2368 | 72 | CCD | G. Samolyk | 0.0001 |
| EW Lyr | 54629.7502 | 14435 | 0.2367 | 100 | CCD | J. Bialozynski | 0.0001 |
| EW Lyr | 54631.6992 | 14436 | 0.2370 | LL | CCD | G. Samolyk | 0.0001 |
| EW Lyr | 54709.6483 | 14476 | 0.2372 | 88 | CCD | G. Samolyk | 0.0001 |
| FL Lyr | 54583.8446 | 7512 | -0.0038 | 83 | CCD | G. Samolyk | 0.0002 |
| FL Lyr | 54594.7376 | 7517 | -0.0015 | 74 | CCD | J. Bialozynski | 0.0002 |
| FL Lyr | 54642.6572 | 7539 | -0.0013 | 108 | CCD | K. Menzies | 0.0001 |
| RU Mon | 54527.6998 | 3566.5 | -0.5022 | 100 | CCD | J. Bialozynski | 0.0003 |
| RU Mon | 54540.6754 | 3570 | -0.0732 | 103 | CCD | G. Samolyk | 0.0002 |
| RW Mon | 54540.6771 | 10944 | -0.0650 | 116 | CCD | G. Samolyk | 0.0001 |
| BB Mon | 54533.6384 | 38013 | -0.0039 | 76 | CCD | G. Samolyk | 0.0002 |
| EP Mon | 54532.5803 | 18852 | 0.0363 | 76 | CCD | G. Samolyk | 0.0002 |
| SX Oph | 54653.6476 | 10301 | -0.0018 | 74 | CCD | G. Samolyk | 0.0003 |
| V508 Oph | 54569.8276 | 27516 | -0.0156 | 50 | CCD | J. Bialozynski | 0.0001 |
| V508 Oph | 54674.6431 | 27820 | -0.0169 | 75 | CCD | G. Samolyk | 0.0003 |
| V839 Oph | 54616.8510 | 34641.5 | 0.2267 | 60 | CCD | J. Bialozynski | 0.0003 |
| V839 Oph | 54620.7381 | 34651 | 0.2284 | 60 | CCD | J. Bialozynski | 0.0002 |
| V839 Oph | 54681.6768 | 34800 | 0.2268 | 82 | CCD | G. Samolyk | 0.0002 |
| V1010 Oph | 54610.8047 | 23696 | -0.1179 | 72 | CCD | G. Samolyk | 0.0007 |

| Table 1. Times o | f minima of | stars in the | AAVSO eclip | sing binary l | program | ı, cont. | | | |
|------------------|-------------|-----------------|-------------|---------------|---------|----------|----------------|-------------------|--|
| Star | HJL 240(| D(min) 0000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error | |
| V1010 OI | oh 54614 | 4.7722 | 23702 | -0.1189 | 80 | CCD | J. Bialozynski | 0.0012 | |
| FL Ori | 54495 | 9.7789 | 5901 | 0.0350 | 65 | CCD | J. Bialozynski | 0.0001 | |
| FZ Ori | 54531 | 1.6460 | 26269 | -0.0603 | 58 | CCD | J. Bialozynski | 0.0003 | |
| GU Ori | 54526 | 5.7072 | 24341 | -0.0420 | 80 | CCD | J. Bialozynski | 0.0003 | |
| U Peg | 54706 | 5.8073 | 48549 | -0.1250 | 121 | CCD | K. Menzies | 0.0001 | |
| TY Peg | 54705 | 9.7014 | 4611 | -0.3090 | 149 | CCD | G. Samolyk | 0.0001 | |
| BB Peg | 54631 | 1.8082 | 30062 | -0.0013 | 64 | CCD | G. Samolyk | 0.0001 | |
| BB Peg | 54658 | 8.7402 | 30136.5 | -0.0012 | 91 | CCD | K. Menzies | 0.0001 | |
| BB Peg | 54678 | 8.8041 | 30192 | -0.0007 | 80 | CCD | G. Samolyk | 0.0001 | |
| BB Peg | 54710 | 0.6143 | 30280 | -0.0027 | 65 | CCD | G. Samolyk | 0.0003 | |
| BG Peg | 54698 | 8.6872 | 4695 | -1.8512 | 76 | CCD | K. Menzies | 0.0007 | |
| BX Peg | 54650 | 0.7799 | 37285 | -0.0868 | 61 | CCD | K. Menzies | 0.0001 | |
| BX Peg | 54702 | 2.6579 | 37470 | -0.0866 | 95 | CCD | G. Samolyk | 0.0001 | |
| DI Peg | 54710 | 0.6180 | 13366 | -0.0133 | 83 | CCD | G. Samolyk | 0.0001 | |
| GP Peg | 54702 | 2.7852 | 13801 | -0.0454 | 86 | CCD | G. Samolyk | 0.0002 | |
| GP Peg | 54706 | 5.6890 | 13805 | -0.0441 | 120 | CCD | K. Menzies | 0.0001 | |
| KW Peg | 52240 | 0.5777 | 5000 | 0.0902 | 30 | CCD | S. Dvorak | 0.0003 | |
| KW Peg | 52602 | 2.653 | 5443.5 | 0.099 | 20 | CCD | G. Samolyk | 0.005 | |
| KW Peg | 52920 |).640 | 5833 | 0.105 | 25 | CCD | R. Poklar | 0.001 | |
| KW Peg | 53589 | €806). | 6652.5 | 0.1185 | 52 | CCD | G. Samolyk | 0.0007 | |

| Table 1. Times of m | inima of stars in the | e AAVSO eclip | sing binary p | orogram | l, cont. | | | |
|---------------------|-----------------------|---------------|---------------|---------|----------|----------------|-------------------|--|
| Star | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error | |
| RT Per | 54534.6799 | 24910 | 0.0596 | 70 | CCD | J. Bialozynski | 0.0001 | |
| RT Per | 54674.8325 | 25075 | 0.0612 | 62 | CCD | G. Samolyk | 0.0002 | |
| RT Per | 54702.8629 | 25108 | 0.0614 | 70 | CCD | G. Samolyk | 0.0001 | |
| IU Per | 54553.6441 | 10434 | 0.0082 | 55 | CCD | J. Bialozynski | 0.0004 | |
| KW Per | 54657.8475 | 13158 | 0.0117 | 71 | CCD | G. Samolyk | 0.0002 | |
| KW Per | 54698.8224 | 13202 | 0.0112 | 75 | CCD | K. Menzies | 0.0001 | |
| Y Psc | 54676.8459 | 2401 | -0.0017 | 74 | CCD | G. Samolyk | 0.0002 | |
| AV Pup | 54127.7825 | 41251 | 0.1155 | 44 | CCD | J. Bialozynski | 0.0003 | |
| AV Pup | 54526.6873 | 41968 | 0.1253 | 73 | CCD | R. Poklar | 0.0001 | |
| AV Pup | 54526.6874 | 41968 | 0.1254 | 60 | CCD | J. Bialozynski | 0.0002 | |
| AV Pup | 54545.6101 | 42002 | 0.1326 | 56 | CCD | G. Samolyk | 0.0002 | |
| U Sge | 54641.7524 | 11096 | -0.0111 | 100 | CCD | J. Bialozynski | 0.0004 | |
| U Sge | 54668.7974 | 11104 | -0.0110 | 158 | CCD | G. Samolyk | 0.0001 | |
| V505 Sgr | 54688.6435 | 8646 | -0.0547 | 106 | CCD | G. Samolyk | 0.0002 | |
| V1968 Sgr | 54590.8583 | 29774 | -0.0132 | LL | CCD | G. Samolyk | 0.0005 | |
| V1968 Sgr | 54651.6890 | 29882 | -0.0135 | 108 | CCD | G. Samolyk | 0.0005 | |
| AO Ser | 54574.7651 | 23246 | -0.0097 | 90 | CCD | J. Bialozynski | 0.0001 | |
| AO Ser | 54610.8172 | 23287 | -0.0109 | 83 | CCD | G. Samolyk | 0.0002 | |
| CC Ser | 54554.7977 | 33085.5 | 0.9046 | 61 | CCD | G. Samolyk | 0.0005 | |
| CC Ser | 54590.6582 | 33155 | 0.9026 | 83 | CCD | G. Samolyk | 0.0005 | |

| | lard or | 002 | 002 | 002 | 002 | 201 | 201 | 201 | 003 | 003 | 201 | 001 | 004 | 201 | 005 | 002 | 900 | 201 | 201 | 201 | 002 |
|-----------------------------|----------------------|----------------|------------|----------------|------------|------------|------------|------------|----------------|------------|----------------|----------------|------------|------------|------------|------------|------------|-------------|------------|------------|----------------|
| | Stan. Err | 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0(| 0.0 |
| | Observer | J. Bialozynski | G. Samolyk | J. Bialozynski | G. Samolyk | K. Menzies | G. Samolyk | K. Menzies | J. Bialozynski | K. Menzies | J. Bialozynski | J. Bialozynski | G. Samolyk | K. Menzies | K. Menzies | K. Menzies | G. Samolyk | J. Virtanen | G. Samolyk | G. Samolyk | J. Bialozynski |
| , cont. | Type | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD | CCD |
| rogram | N | 59 | 76 | 80 | 75 | 104 | 73 | 91 | 109 | 32 | 60 | 55 | 87 | 50 | 82 | 53 | 52 | 83 | 48 | 40 | 12 |
| e AAVSO eclipsing binary pi | 0-C | 0.0531 | 0.2474 | 0.0550 | -0.0254 | -0.0039 | -0.0717 | -0.0584 | 0.1851 | 0.2535 | 0.2546 | 0.2541 | 0.2523 | 0.2545 | 0.2557 | 0.2560 | 0.2551 | 0.0019 | 0.0019 | 0.0017 | 0.0018 |
| | Cycle | 40544 | 30947 | 24735 | 42465.5 | 51663 | 12535 | 26322 | 3121 | 42350.5 | 42365 | 42367.5 | 42390.5 | 42426.5 | 42500 | 42556.5 | 42728.5 | 86879 | 86956 | 87012 | 87079 |
| ninima of stars in the | HJD(min) 2400000+ | 54529.7351 | 54533.5631 | 54537.6920 | 54708.8335 | 54707.7832 | 54680.8430 | 54547.6861 | 54558.6990 | 54547.6370 | 54552.7789 | 54553.6647 | 54561.8173 | 54574.5829 | 54600.6427 | 54620.6744 | 54681.6542 | 54519.4264 | 54534.5701 | 54545.5835 | 54558.7606 |
| Table 1. Times of m | Star | RZ Tau | TY Tau | WY Tau | EQ Tau | V Tri | X Tri | W UMa | TX UMa | TY UMa | TY UMa | TY UMa | TY UMa | TY UMa | TY UMa | TY UMa | TY UMa | UX UMa | UX UMa | UX UMa | UX UMa |

| Star | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error |
|-----------------|----------------------|---------|---------|-----|------|----------------|-------------------|
| UX UMa | 54659.6532 | 87592 | 0.0020 | 56 | CCD | G. Samolyk | 0.0001 |
| VV UMa | 54527.8287 | 12675 | -0.0493 | 76 | CCD | K. Menzies | 0.0001 |
| VV UMa | 54536.7646 | 12688 | -0.0493 | 60 | CCD | J. Bialozynski | 0.0002 |
| VV UMa | 54547.7630 | 12704 | -0.0490 | 57 | CCD | K. Menzies | 0.0001 |
| XZ UMa | 54631.6740 | 6924 | -0.0957 | 64 | CCD | G. Samolyk | 0.0002 |
| ZZ UMa | 54538.7003 | 8084 | -0.0015 | 80 | CCD | J. Bialozynski | 0.0002 |
| ZZ UMa | 54554.7948 | 8091 | -0.0019 | 80 | CCD | G. Samolyk | 0.0002 |
| RU UMi | 54596.6423 | 24766 | -0.0160 | 83 | CCD | G. Samolyk | 0.0002 |
| VV Vir | 54590.6641 | 52382 | -0.0378 | 78 | CCD | G. Samolyk | 0.0001 |
| VV Vir | 54606.7243 | 52418 | -0.0385 | 76 | CCD | J. Bialozynski | 0.0003 |
| AG Vir | 54592.7499 | 14254 | -0.0085 | 80 | CCD | J. Bialozynski | 0.0009 |
| AH Vir | 54562.6381 | 21466.5 | 0.2036 | 115 | CCD | G. Samolyk | 0.0002 |
| AH Vir | 54588.7201 | 21530.5 | 0.2042 | 80 | CCD | J. Bialozynski | 0.0004 |
| AH Vir | 54598.7035 | 21555 | 0.2033 | 70 | CCD | J. Bialozynski | 0.0011 |
| AK Vir | 54588.7297 | 10064 | -0.0496 | 80 | CCD | J. Bialozynski | 0.0001 |
| AW Vir | 54561.8213 | 26947 | 0.0205 | 89 | CCD | G. Samolyk | 0.0001 |
| AW Vir | 54596.6912 | 27045.5 | 0.0217 | 51 | CCD | G. Samolyk | 0.0003 |
| AW Vir | 54597.7531 | 27048.5 | 0.0216 | 60 | CCD | J. Bialozynski | 0.0003 |
| AZ Vir | 54554.7638 | 30252.5 | -0.0199 | 94 | CCD | G. Samolyk | 0.0002 |
| $\Lambda T Mir$ | 0272 4244 | 20757 5 | 0.0100 | 70 | | I Dialographic | |

| Table 1. Times of 1 | ninima of stars in the | e AAVSO eclip | sing binary l | program | ı, cont. | | | |
|---------------------|------------------------|---------------|---------------|---------|----------|----------------|-------------------|-----|
| Star | HJD(min) 2400000+ | Cycle | 0-C | Ν | Type | Observer | Standard Error | 1 |
| AZ Vir | 54610.7099 | 30412.5 | -0.0203 | 77 | CCD | G. Samolyk | 0.0002 | i i |
| BH Vir | 54577.7653 | 13891 | -0.0072 | 85 | CCD | J. Bialozynski | 0.0002 | |
| BH Vir | 54590.8350 | 13907 | -0.0075 | 88 | CCD | G. Samolyk | 0.0001 | |
| Z Vul | 54674.6895 | 4777 | -0.0079 | 78 | CCD | G. Samolyk | 0.0001 | |
| AW Vul | 54684.6440 | 10415 | -0.0124 | 93 | CCD | G. Samolyk | 0.0003 | |
| AW Vul | 54688.6765 | 10420 | -0.0122 | 88 | CCD | G. Samolyk | 0.0001 | |
| AX Vul | 54596.8826 | 4812 | -0.0307 | 74 | CCD | G. Samolyk | 0.0005 | |
| BE Vul | 54672.7225 | 9382 | 0.0647 | 136 | CCD | G. Samolyk | 0.0001 | |
| BO Vul | 54708.6609 | 9620 | -0.0299 | 76 | CCD | G. Samolyk | 0.0001 | |
| BS Vul | 54596.8208 | 23794 | -0.0224 | 87 | CCD | G. Samolyk | 0.0002 | |
| BS Vul | 54637.7543 | 23880 | -0.0224 | 60 | CCD | J. Bialozynski | 0.0001 | |
| BS Vul | 54688.6830 | 23987 | -0.0227 | 68 | CCD | G. Samolyk | 0.0001 | |
| BS Vul | 54709.6259 | 24031 | -0.0225 | 68 | CCD | G. Samolyk | 0.0001 | |
| BT Vul | 54674.7683 | 16888 | 0.0027 | 67 | CCD | G. Samolyk | 0.0002 | |
| BU Vul | 54630.8214 | 37078 | 0.0159 | 60 | CCD | E. Wiley | 0.0002 | |
| CD Vul | 54636.7753 | 12195 | 0.0000 | 80 | CCD | J. Bialozynski | 0.0002 | |
| CD Vul | 54651.8182 | 12217 | 0.0005 | 63 | CCD | G. Samolyk | 0.0003 | |

Frequency Analysis of Long-term AAVSO Visual Observations of TU Cas

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Received June 11, 2008; revised August 14, 2008; accepted August 29, 2008

Abstract Forty years of visual data in the AAVSO International Database for the double-mode Cepheid variable TU Cas were analyzed for possible changes in pulsation frequency and amplitude. The data were divided into four epochs for frequency analysis to search for any changes in the pulsation periods. The fundamental and first-overtone periods showed no significant variation during the forty-year span. The values determined for these frequencies agree well with other studies based on PMT and CCD data.

1. Introduction

TU Cas is a member of the "beat" or "double-mode" δ Cephei class of variable stars. These stars pulsate in two frequencies, usually the fundamental and first overtone (1O) radial modes, rather than the single frequency seen in normal Cepheid variables. Several studies of TU Cas' pulsation modes have been published, the most recent being Pardo and Poretti (1997), based on several decades of CCD and photomultipier tube (PMT) data. An analysis by Faulkner (1977) detected the presence of a second overtone frequency, although this has not been confirmed by later studies.

Studies of beat Cepheids have suggested that the fundamental and first overtone pulsations may change in frequency and/or amplitude ratios on time scales of decades. Hodson *et al.* (1979) proposed that the *V* amplitude of the first overtone had decreased by 40%, based on nearly seventy years of data. The AAVSO International Database contains almost 5,000 visual observations of TU Cas spanning sixty years. An analysis of this large data set was undertaken to search for any changes in the pulsation periods or amplitudes.

2. Analysis

The AAVSO visual data (AAVSO 2008) exhibited four distinct epochs of increased observation activity, separated by periods of relatively low activity. These four epochs were analyzed separately to search for long-term variations in amplitude ratio or pulsation frequencies. Table 1 shows the statistics for each of the four epochs. A single data point from JD 2432480 (October 1947) was omitted from data set 1 because it was more than 7,000 days from the nearest data point and introduced a number of aliases in the frequency analysis. After

omitting this data point the complete set of data used for analysis covered 41.6 years and contained 4,948 data points.

The AAVSO database includes the AAVSO Observer Initials (unique observer identification) for each data point. The data in sets 1, 3, and 4 were normalized by adjusting the measurements for observers with large numbers of observations (generally more than eighty points) such that the average for the observer matched the average of the entire set. Generally this adjustment was on the order of 0.1 to 0.2 magnitude. Data set 1 was also adjusted by +0.20 magnitude to shift its average to match the other three data sets; this offset is most likely due to changes in comparison star magnitude values or due to the use of different comparison star sequences. Observer-specific adjustments were not applied to data set 2 because the bulk of the observations (over 90%) were contributed by a single observer. The adjusted data in sets 1, 3, and 4 and the unadjusted data from set 2 were also merged into a single forty-two-year collection (referred hereafter as the "combined" data set) and analyzed in the same manner as the individual data sets.

Frequency analysis of each data set was conducted using PERIOD04 (Lenz and Breger 2004). After zero-point-subtraction, Fourier analysis in the range of 0 < f < 2d was performed and the strongest signal was selected. PERIOD04's least squares fit was run using the selected frequency to find the best amplitude, phase, and frequency. The Fourier analysis and least squares fit was repeatedly performed using the residuals from the previous iteration, with the strongest signal found in each cycle being added to the list of fitted frequencies. The Fourier analysis and fitting cycle was terminated when the residuals value determined by PERIOD04 was no longer decreasing. The signal-to-noise ratio (SNR) was then determined using a box size of 5 for each frequency in each fitted set. Frequencies with SNR < 4 were eliminated from each data set. The residuals in each data set were on the order of 0.2 magnitude after fitting these significant frequencies. Sample power spectra for the combined data set are shown in Figures 1 through 3.

3. Results and Discussion

Tables 2 through 6 list all frequencies with SNR > 4 found in data sets 1 through 4, and the combined set, respectively. Each table lists the frequency, the calculated visual magnitude amplitude and the error estimates (in parentheses) from the least squares fit, along with the SNR calculated using PERIOD04's Calculate Noise module.

The fundamental radial mode (f0) was the most significant frequency in all data sets. The first overtone (f1) was also detected in all data sets, though in Data Sets 1 and 2 it was detected as a 1-day alias (1-f1). Most of the data after JD 2451667 (May 2000) used the standard AAVSO chart of the field dated "12/96." The AAVSO data before this date also do not include comparison

star information, making it impossible to adjust the estimates based on the comparison sequence on the 12/1996 chart. Data prior to the chart issuance in December 1996 presumably used a variety of comparison star sequences, resulting in significantly noisier data that obscures the overtone and coupled frequencies.

The data in sets 3 and 4 were all collected after the standard chart was issued in 1996, and the analysis of these sets revealed additional frequencies above the SNR = 4 threshold. Significant frequencies were detected with amplitudes down to 0.04 magnitude in both data sets. This result validates the value of visual estimates, and is impressive, given the large number of observers, the uncalibrated nature of the data, and the fact that visual estimates were only reported to 0.1 magnitude precision.

The fundamental radial mode and first overtone were detected in all four individual data sets. The primary mode (f0) had values of 0.46744(1), 0.46748(3), 0.46745(1), and 0.46746(1) cd⁻¹ in sets 1 through 4, respectively. The first overtone frequency, f1, had values of 0.65862(2), 0.65864(6), 0.65863(2), and 0.65865(2) cd⁻¹ in data sets 1 through 4, respectively. These values all agree within 1 σ and do not indicate any statistically significant variation between the epochs, in agreement with the findings of 0.467442 and 0.658635 reported in that paper.

The combined data set Fourier analysis yielded values of 0.467448(2) cd⁻¹ and 0.658655(9) cd⁻¹ for f0 and f1, respectively. The value for f1 is consistent with Pardo and Poretti (1997), but f0 is only marginally consistent with the value of 0.467442 reported in that paper. No error estimate for the frequencies are given in the Pardo and Poretti paper so the significance of this discrepancy cannot be definitively evaluated. After prewhitening these two frequencies a weaker peak was detected for each of the two modes. These residuals had frequencies of 0.467482(6) and 0.65868(2) cd⁻¹ for f0 and f1, respectively; Figure 3 shows the residual f0 signal. These signals indicate that the frequencies of the two pulsation modes may have changed during the forty-two-year span, possibly switching between the two frequencies detected for each mode. The low sampling rate in the data set makes it difficult to do a finer analysis since further subdividing of the individual data sets will result in larger error values, overwhelming any frequency changes.

The second overtone frequency that Faulkner (1977) detected at f=0.79843 cd⁻¹ is not detected in any of the data sets. Faulkner found an amplitude of 0.05 magnitude for this pulsation, somewhat greater than the 0.035-magnitude amplitude found for the weakest signal above the SNR = 4 cutoff in this study. This non-detection is in agreement with Matthews *et al.* (1992), who did not detect any additional overtone frequencies at the 0.004-magnitude level.

In addition to frequency changes, some studies have suggested that the relative amplitudes of the primary and first overtone pulsations have changed on decade time scales, with Hodson *et al.* (1979) proposing a 40% change over seventy years. The ratio of brightness amplitudes between f0 and f1 in data sets 1 though 4 have values of 2.5(5), 2.3(6), 2.7(2), and 2.4(2), respectively. The error estimates for these ratios are rather high, especially in data sets 1 and 2, due to the uncertainties in the amplitudes from the Fourier analysis. Assuming that the 40% change over seventy years detected by Hodson *et al.* is reasonably linear, we would expect to see roughly a 25% change in the AAVSO data set, but the amplitude ratios do not vary at a statistically significant level, and a 25% change over the period can be ruled out.

4. Conclusions

Frequency analysis of the forty-two years of visual data for TU Cas in the AAVSO International Database yielded good measurements of the star's primary and first overtone pulsation frequencies. The values are in good agreement with studies performed using PMT and CCD measurements with much higher precision, showing the value of the AAVSO visual data. The frequencies determined from the AAVSO data are in good agreement with previous studies, and also confirm that they have remained stable over at least the last four decades.

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| Data Set | Date Range (JD) | Number of Observations | Average Observations per Day | Average Magnitude (unadjusted) |
|----------|--------------------|---------------------------|------------------------------------|--------------------------------------|
| 1 | 2439340-2444217 | 1245 | 0.26 | 7.65 |
| 2 | 2444577-2446787 | 334 | 0.15 | 7.88 |
| 3 | 2448673-2452730 | 1462 | 0.36 | 7.84 |
| 4 | 2452752-2454519 | 1907 | 1.08 | 7.86 |
| Combined | 2439340-2454519 | 4948 | 0.33 | n/a |

Table 1. AAVSO data sets for TU Cas.
| Frequency ID | Frequency (c/d) | Amplitude (V mag) | SNR | |
|-----------------|--------------------|----------------------|------|--|
| f0 | 0.46744(1) | 0.16(1) | 11.7 | |
| 1-day artifact | 1.00143(2) | 0.07(1) | 5.3 | |
| 2f0 | 0.93542(3) | 0.06(1) | 4.5 | |
| 1 <i>f1</i> | 0.34138(2) | 0.06(1) | 4.7 | |
| 1-day artifact | 1.00512(3) | 0.06(1) | 4.6 | |

Table 2. Frequency analysis results for data set 1.

Table 3. Frequency analysis results for data set 2.

| Frequency ID | Frequency (c/d) | Amplitude (V mag) | SNR |
|-----------------|--------------------|----------------------|------|
| f0 | 0.46748(3) | 0.27(2) | 13.9 |
| 1 <i>-f1</i> | 0.34136(6) | 0.12(2) | 6.0 |
| f0+f1 | 1.12607(9) | 0.10(2) | 4.9 |
| 2 <i>f</i> 0 | 0.93494(9) | 0.09(2) | 4.5 |

Table 4. Frequency analysis results for data set 3.

| Frequency ID | Frequency (c/d) | Amplitude (V mag) | SNR |
|-----------------|--------------------|----------------------|------|
| f0 | 0.46745(1) | 0.286(7) | 30.5 |
| fl | 0.65863(2) | 0.105(7) | 11.2 |
| 2f0 | 0.93487(2) | 0.097(7) | 10.4 |
| f0+f1 | 1.12609(2) | 0.069(7) | 7.4 |
| 2f0+f1 | 1.59362(3) | 0.061(7) | 6.5 |
| f0-f1 | 0.19125(4) | 0.038(7) | 4.0 |

Table 5. Frequency analysis results for data set 4.

| Frequency ID | Frequency (c/d) | Amplitude (V mag) | SNR |
|-----------------|--------------------|----------------------|------|
| f0 | 0.46746(1) | 0.292(7) | 33.2 |
| f1 | 0.65865(2) | 0.122(7) | 13.8 |
| 2f0 | 0.93492(3) | 0.103(7) | 11.7 |
| f0+f1 | 1.12612(4) | 0.078(7) | 8.9 |
| 2f0+f1 | 1.59354(5) | 0.053(7) | 6.0 |
| 1-day artifact | 1.00191(5) | 0.055(7) | 6.2 |
| 3 <i>f</i> 0 | 1.40236(7) | 0.040(7) | 4.6 |
| f0-f1 | 0.19106(7) | 0.042(7) | 4.7 |
| 1-day artifact | 0.99761(6) | 0.043(7) | 4.9 |
| <i>f0</i> alias | 1.46980(7) | 0.039(7) | 4.4 |

| Frequency | Frequency | Amplitude | SNR |
|------------------|-------------|-----------|------|
| ID | (c/d) | (V mag) | |
| f0 | 0.467448(2) | 0.229(9) | 40.5 |
| fl | 0.658655(2) | 0.10 (5) | 18.1 |
| 2f0 | 0.934890(2) | 0.088(4) | 15.6 |
| f0 lobe | 0.467482(6) | 0.081(4) | 14.3 |
| f0+f1 | 1.126101(2) | 0.064(4) | 11.4 |
| <i>f1</i> lobe | 0.65868 (2) | 0.05 (5) | 8.8 |
| ? | 0.000170(3) | 0.048(6) | 8.6 |
| 2f0+f1 | 1.593534(3) | 0.047(4) | 8.3 |
| 1-day artifact | 0.998283(5) | 0.033(5) | 5.9 |
| 1-day artifact | 1.001848(5) | 0.030(5) | 5.2 |
| 3f0 | 1.402312(5) | 0.030(4) | 5.4 |
| f0f1 | 0.191200(5) | 0.030(4) | 5.2 |
| 1-day artifact | 2.005046(5) | 0.028(5) | 4.9 |
| 1-year artifact? | 0.001403(5) | 0.028(5) | 5.0 |
| 1-day artifact | 0.994755(5) | 0.027(4) | 4.8 |
| ? | 2.397052(6) | 0.025(4) | 4.5 |
| 4 <i>f</i> 0 | 2.525188(6) | 0.024(4) | 4.2 |
| 1-month artifact | 0.032680(6) | 0.022(4) | 4.0 |
| 4 <i>f</i> 0 | 2.525188(6) | 0.024(4) | 4.2 |

Table 6. Frequency analysis results for the combined data set.



Figure 1. The initial Fourier spectrum for the combined data set, prior to prewhitening steps. Frequencies f0, f1, and their multiples and cross-terms are readily apparent, as well as several aliases and sampling artifacts.



Figure 2. An enlarged view of the initial Fourier spectrum for the combined data set showing the region around f0 and f1.



Figure 3. The same enlarged view as Figure 2, after prewhitening with the primary frequency found for f0. Note the residual signal from f0 that remains, near 0.46 cd⁻¹.

Abstracts of Papers and Posters Presented at the 96th Annual Meeting of the AAVSO, Held in Cambridge, Massachusetts, November 1–3, 2007

BVRI Photometry of CX Cephei (WR 151)

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Abstract The CX Cephei system is a double-line spectroscopic, eclipsing binary, consisting of an O5V and a WN5 (Woft-Rayet star) component. It has the second shortest known period (2.12691d) among O + WR binaries. The primary eclipse is shallow (approx. 0.1 magnitude) and the secondary eclipse even shallower. There is other variability also, accounting for a total range of approx. 12.0 to 12.2 in Lipunova and Cherepashchuk 1982 (Sov. Astron. 26, 45-53) published photometry data from the 1980's. Lewis et al. 1996 (ApJ 405, 312–326) published radial velocity data, showing that the WR star is in front at primary minimum. To this we add 340+ BVRI points over two years from the Sonoita Research Observatory (SRO), plus assorted time series from Sonoita (by HQA) and from Starhouse Observatory (by KMP). From our observations, we were able to, 1) refine the period given by Lipunova and Cherepashchuk, and show that, 2) there is intrinsic variability in addition to the eclipsing binary light curve, 3) that, unlike the 1980s, the secondary eclipse is now barely detectable, 4) there may or may not be additional "structure" in the eclipsing light curve, 5) and that the light curve varies with color. We see that the minima are pointed (eclipse not total), that the minima have a distinct beginning and end, although there are "shoulders" (ellipticity is important, but sky is seen between the stars at quadrature), that the eclipses are very shallow (low i, barely eclipsing). There is a dimward slope between phase 0.2 and 0.8, ranging from 2.5% in flux in B and V, to less than 1% in I. It seems unlikely that the WR core is substantially cooler than even an O5, so the primary minimum is expected to be at least partly an "atmospheric" eclipse caused by the WR wind (as Lipunova and Cherepashchuk modeled it), rather than the star itself. However, the primary minimum is one of the most stable features with time, so the wind opacity and configuration must not be responsible for observed changes. Changes in the secondary minima must be due to changes in what the O5 is eclipsing. We have not vet modeled all this!

On the Classification of V3798 Sgr

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Abstract In 1972 D. Hoffleit classified V3798 Sgr as an RV Tau variable star. However Springob et al. (1998) suggested that it could be an UXOR-a star with sporadic drops of brightness. A retrospective study of the variability of the star was conducted using the Harvard Plate Collection. More than 250 plates were looked at with more than 120 measurements made. The plates were exposed as early as 1895 and as late as 1949. In addition the star was monitored in BVRI with a CCD camera on the Maria Mitchell Observatory (MMO) 24-inch telescope in 2007. In our study of V3798 Sgr, in both our CCD photometry and the plate study, sporadic drops of brightness were confirmed, measuring up to 1.3 magnitudes, within a broad range of time scales-from a year to an hour. No periodicity was detected. Spectra of the star showed typical early A absorption line spectrum with variable narrow emission in the cores of H- α and other absorption lines. A dramatic emission line flare was observed on September 19, 2007, with an increase of H- α equivalent width by a factor of 4 relative to the previous observation, five nights before. No continuum photometry is available for September 19 but the brightness in R two days before and one day after that date differs by only 0.07 magnitude. A closer synchronism of spectroscopy and photometry is needed to verify the lack of correlation between the variations of the emission lines and continuum. So far, the lack of periodicity and an early spectral type seem to disprove the classification of V3798 Sgr as an RV Tau star and support the hypothesis that it is an UXOR. We thank A. Doane for help with measuring the plates and P. Berlind, M. Calkins and O. Shemmer for taking the spectra. This project was supported by the NSF/REU grant AST-0354056 and the Nantucket Maria Mitchell Association

AH Leo: 2004–2007

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Abstract The RR Lyrae star AH Leo has a distinct RRab light curve with a superimposed amplitude modulation and variation in time of maximum light.

During the 2004 through 2007 observing seasons observations were obtained to try and document observed effects, including an AAVSO observing campaign in 2006. In this presentation we discuss the data validation that was used to bring the campaign data inline with other data, discovered periodicities, and changes in the light curves shape over the four seasons of data.

Time Series Observations of IP Pegasi Using an Inexpensive Ambient Temperature CCD Camera

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Abstract IP Pegasi is an eclipsing cataclysmic variable star. The system occasionally goes into outburst due to accretion disk instabilities. Observations at quiescence were collected with a 20-cm aperture Schmidt Cassegrain Telescope. The images were recorded with a Meade DSI-Pro CCD camera. Co-adding was required to eliminate noise due to the ambient temperature CCD detector. The observations were unfiltered. AAVSO V-filtered and unfiltered observations were obtained during outburst. One objective of this study was to obtain time series photometric data from the low cost camera. This camera successfully provided unfiltered light curves of cataclysmic variable stars. A second objective was to analyze light curves of IP Pegasi and determine a probable structure of the system. The light curve during outburst displays a high luminosity midway between narrow eclipses. During quiescence, the peak intensity occurs just before the eclipse begins, and the eclipse is not symmetrical. The light curves support the belief that during outburst the brightest region lies in the vicinity of the white dwarf. During the quiescent state, the brightest regions of the system appear to be distributed among the red dwarf, the white dwarf, and the hot spot on the perimeter of the accretion disk. This study was funded by the American Astronomical Society, Small Projects Grant. It was also funded by the North Carolina Academy of Sciences, Yarbrough Grant.

Search for Dwarf Novae in DASCH Scans Near M44

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Abstract Dwarf novae (DNe) are a subclass of Cataclysmic Variables (CVs) with outbursts powered by a disk instability leading to a sudden increase in the accretion rate. The Digital Access to a Sky Century at Harvard (DASCH) Collaboration is preparing to digitize over 500,000 Harvard plates from the 1880s to the 1980s with limiting magnitudes ranging from B = 14-19. As a demonstration project, we have scanned more than 500 plates in the fields centered on the galactic open cluster M44. There are twenty-one CVs in the fields within ten degrees of M44 covered by the scans Here we present the preliminary results of DN outbursts of the known CVs to derive long-term DN outburst duty cycles. In addition, a one hundred year light curve for a XMM-Newton source is also presented to demonstrate DASCH capabilities.

High Speed Photometry of V455 Andromedae With a Small Telescope (poster)

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Abstract The recent eruption of V455 Andromedae to brighter than magnitude 11 has enabled unfiltered high speed photometry for this system. In mid-September 2007 the star was sufficiently bright that observations every thirteen seconds were acquired using a small telescope (20 cm SCT) and SBIG ST7 CCD camera. Fourier transform techniques detected a strong signal at 68 seconds-per-cycle on September 22-23, 2007 (JD 2454366.6) when the system brightness was about magnitude 12.5. Faint signals at 67 seconds were detected on earlier dates: September 18-19 (JD 2454362.6) and September 19-20, 2007 (JD 2454363.6). Fainter signals were also detected on later dates: September 28-29 (JD 2454372.6) at 71 seconds, and October 5-6 (JD 2454379.6) at 71 seconds. No isolated signals at the short 67-71 second periods were detected on other dates: JD 2454360.0, JD 2454381.6, and JD 2454388.6 (September 15-16, October 7-8, and October 14-15). When the 67-70 second signals were the strongest, the turbulence in the light curve was visibly weakest leading to a strong isolated short period signal. It is hypothesized that the short signal may be closely linked to the rotation period of the white dwarf at the core of the accretion disk. The large signal on one of the dates may indicate a temporary

brightening of a hot spot on the surface of the white dwarf. Students Emily Woodall, Alex Pearce, Gordon Jones, and Ted Risberg assisted the observations and analysis. This study was supported by the American Astronomical Society Small Projects Grants Program.

The Challenge of Finding the Comet for the Deep Impact Extended Mission

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Abstract The spectacular success of the Deep Impact mission coupled with adequate fuel reserves led to the authorization for the Deep Impact project to perform a maneuver on 2005 July 24 that would bring the flyby spacecraft back to the Earth's neighborhood in late 2007 for an extended mission to another comet. The goal of the extended mission will be to explore the diversity of comets, exploring the range of cometary topography, activity, thermal properties and chemistry. There were two possible comets accessible to the spacecraft: 103P/Hartley and 85P/Boethin. Of the two, 85P/Boethin is a much more desirable target. In order to re-direct the spacecraft to the comet, preparations for the December Earth-flyby maneuver are to begin with deep space maneuvers in early November 2007. On January 4, 1975, one day prior to its perihelion passage, short period comet 85P/Boethin was discovered by Reverend Leo Boethin in the Philippines. The comet was followed until early June. With an orbital period of 11.23 years, the comet was expected at its next perihelion passage in January 1986. It was recovered by Alan Gilmore and Pam Kilmartin in New Zealand on October 11, 1985 and followed just beyond its perihelion passage (January 16) until March 1986. Due to very poor observing conditions when the comet reached perihelion near superior conjunction, the comet was not observed during its most recent return to perihelion in April 1997. This comet gets bright enough for small telescope observations right near perihelion and the dust and gas coma and tail becomes visible approximately three months before perihelion. In order to fully map the orbit, observations are needed at three apparitions. This paper will discuss the role that small telescopes can play and will report on our attempts to recover this comet for a third apparition, in what is turning out to be the most challenging comet recovery ever done, using most of the world's largest telescopes. We will know by October 19 if we have a mission target!

Variable Star Spectroscopy: Tools, Techniques, and Recent Results

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Abstract For well over a century, variable star observers have catalogued changes in the brightness of thousands of variable stars. In contrast, there have been very few efforts to monitor changes in variable star spectra over time. This is unfortunate, because spectroscopic observations of variable stars can provide important additional information about the complex physical processes occurring within and around the star itself. For example, the presence of hydrogen emission lines in the spectra of Mira variables indicates the presence of shock waves in the upper atmospheres of these stars.

In this presentation, I will describe some of the resources available for making spectroscopic observations of variable stars with small telescopes, including spectrographs for data acquisition and software for data reduction and analysis. The process of observing a stellar spectrum will also be described, from image acquisition, through wavelength and flux calibration, to the extraction of stellar parameters such as spectral class and atmospheric composition. Finally, I will present results from ongoing research at the Truman State University Observatory to monitor spectral changes in Mira and semiregular variable stars.

Have Scope—Will Travel

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Abstract Since retiring from daily classroom teaching I have developed a program for bringing astronomy instruction and observing parties to elementary schools in southeastern Massachusetts through the existing parent-teacher organizations. In this paper I will show excerpts from my atmospheric, lunar, planetary, solar and stellar presentations as well as a few pictures of student star parties and public sidewalk astronomy.

The New DASCH Web Page (poster)

Edward J. Los

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Abstract DASCH is "Digital Access to a Sky Century at Harvard," the effort to digitize approximately 500,000 astronomical plates in the Harvard College Observatory collection. The project to date has generated 700 GB of images with 41 MB of supporting data. This paper describes a prototype web site designed to give researchers easy access to this information.

HI STAR: Building Bridges Between AAVSO Observers and High School Students

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Abstract How did a Hawaiian high school student get to use a telescope in Indiana, via the internet, to observe celestial objects of her choosing? It was thanks to an AAVSO member who generously shared his telescope time. Donn Starkey not only shared his telescope and expertise with this student, but with seventeen others this past summer at HI STAR, the Hawaii Student Teacher Astronomy Research program hosted at the University of Hawaii. This weeklong "astronomy camp" for middle and high school students included lectures, activities, and—the highlight—observing. After just one week, all students, who had little to no background in astronomy, were able to begin astronomy research projects which they can continue at their schools. The content areas ranged from tracking asteroids, to doing photometry of variable stars, and calculating the rotational velocities of galaxies. We'll discuss highlights of the program, including how astronomers of all types can become involved with such promising students.

Hands-On Astrophysics and the Science Olympiad

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Abstract The *Hands-On Astrophysics* curriculum package is being converted to a web-based product in PDF format. Most of the student chapters have now been converted, with images substitutions and minor text revisions. It is anticipated that the entire student and teacher pages will be converted by spring. The pages will soon be placed on the AAVSO website so that AAVSO staff can enhance the materials with internal links and other materials. The membership is invited to view the status of the chapters and give input as to what should be done to improve *Hands-On Astrophysics* for amateur astronomers. Also, these materials as well as the AAVSO website are major resources for the National Science Olympiad high school astronomy event. There are other sites with Science Olympiad resources as well, and these will be shown to the membership so that if they are invited to assist Science Olympiad coaches with variable star astronomy, they will know where the resources are and how they can best meet the needs of the coaches.

Light and Optics Demonstrations for Astronomy

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Abstract How can you excite your audience about astronomy and telescopes when you have your star parties? What happens to the light coming from distant nebula or planet as it goes through the telescope to your eye? A basic physics review with demonstrations using mirrors and lenses will be used to answer this question. You will experience a discrepant phenomenon with an unexpected outcome. This creates a sense of wonder and the need for an explanation, motivating the person to learn more science. This is the goal of educational outreach, sharing a passion and wanting others to feel that same passion for astronomy.

The Orbit of Venus—A Lab Exercise

Ronald E. Zissell

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Abstract Galileo observed the phases of Venus and concluded that it orbited the Sun. Students can use a modest sized telescope to make observations that will enable them to plot the orbit and determine its size along with the period.

Maria Mitchell: Portrayed in a New Biography

Barbara L. Welther

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Abstract Margaret Moore Booker, a longtime resident of Nantucket, has just published the results of her extensive research in many archives for additional material about "America's first woman astronomer." The result is a very illuminating and well-written portrait of Mitchell as an innovative force in women's education and an inspiring leader in the movement for women's rights. This paper will review some of the well-known details of Mitchell's life and show how Booker's work sheds new light on her subject's persona.

Extending Maria's Legacy

Gary Walker

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Abstract Maria Mitchell Observatory (MMO) has long been the leader in Research Education for Undergraduates. This rich legacy includes over thirty-five Ph.D.s during its fifty-year history of programs initiated by Dorrit Hoffleit. A PREST Grant by the NSF purchased a 24-inch RC telescope and CCD camera which have brought MMO into the 21st Century. Additional initiatives will bring a 17-inch telescope on-line this Spring. Six student projects from Summer 2007 are highlighted. The Author also details "The Thrill of Discovery and the Agony of the Arne-fact (Artifact)."

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Photometry, Spectroscopy, and Classification of Nova V475 Scuti: Erratum

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Received October 7, 2008; accepted October 7, 2008

In the paper "Photometry, Spectroscopy, and Classification of Nova V475 Scuti" by D. Starkey (*JAAVSO*, 2005, **34**, 36–42), there is an error in Equation (2), the descriptions of Equations (2) and (3) should be amended, and a fourth equation and its description should be added.

Equation (2) should read:

$$"M_{y} = -7.92 - 0.81 \arctan \{ (1.32 - \log (t_{2})) / 0.23 \}$$
(2)".

The description of Equation (2) should read: "where M_v equals the absolute *V*-band magnitude of the nova, t_2 is the time in days for the nova to drop exactly two magnitudes in brightness in the *V*-band, and the value of the arctangent is in radians."

The description for Equation (3) should read: "where m_v equals the apparent or observed magnitude of V475 Sct at maximum, D equals the distance to the nova in pc, and A_v is the total galactic absorption of the light path to the nova in V-band magnitudes."

A fourth equation, and descriptive text should be added as follows: "The total galactic absorption can be determined by:

$$\mathbf{A}_{\mathbf{v}} = \mathbf{a}_{\mathbf{v}} \times \mathbf{D} \tag{4}$$

where a_v is the galactic absorption factor of 1.9 V mags/kpc."

NOTES