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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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Complete table of contents inside...

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3) accompanied by an abstract of no more than 100 words.
4) not more than 2,500-3,000 words in length (10–12 pages double-spaced).

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2) have all coordinates labeled with division marks on all four sides;
3) be accompanied by a caption that clearly explains all symbols and significance, so that the reader can understand the figure without reference to the text.

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Photographs and halftone images will be considered for publication if they directly illustrate the text.

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1) provided separate from the main body of the text;
2) numbered sequentially and referred to by Arabic number in the text, e.g., Table 1.

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

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

Table of Contents continued on next page

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.

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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: $\mathrm{M/M} = 20$, $\mathrm{T_{eff}} = 3570\mathrm{K}$, $\log \mathrm{R/R} = 3.09$, $\mathrm{M_{bol}} = -8.62$.

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:

$$\langle u(x) \rangle^2 = 2\alpha^2 + x\varepsilon^2 \qquad (1)$$

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 <u(x)> 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 *<u(x)>* 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 *<u(x)>* 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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Table 1. (O–C) Analyses of BC Cyg.

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

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.

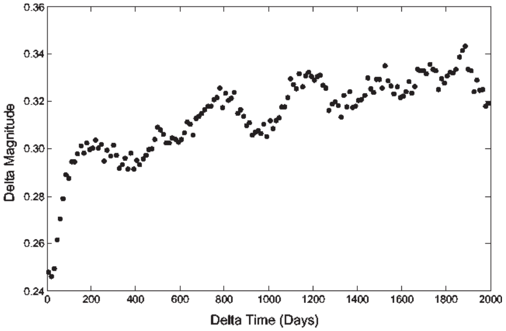

Figure 2. The self-correlation diagram (Δmag versus Δtime) for XX Per. The minima are very shallow, corresponding to amplitudes less than 0.02, and do not repeat in any coherent pattern. The literature period is 415 days, and the self-correlation diagram is not inconsistent with this.

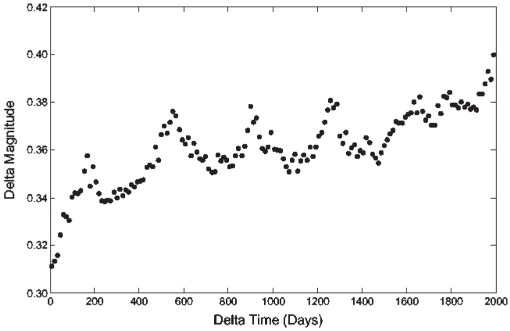

Figure 3. The self-correlation diagram (Δmag versus Δtime) for CE Tau. There are repeating minima at multiples of 375 days, indicating that this is the dominant time scale in the data. The literature period is 140–165 days.

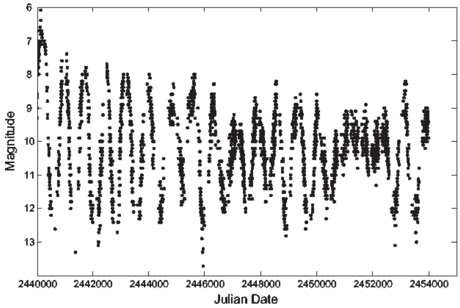

Figure 4. A 15000-day light curve of VX Sgr, based on visual observations from the AAVSO International Database. Note the epoch at which the amplitude becomes small, and the times of maximum and minimum become nearly impossible to determine.

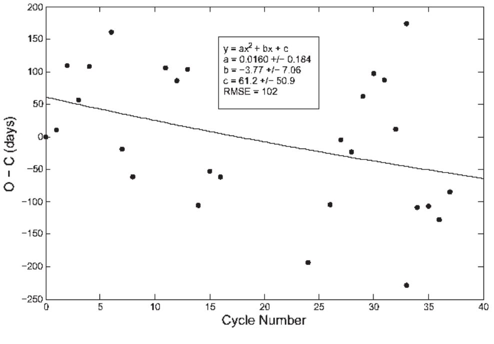

Figure 5. The (O–C) diagram for BC Cyg, using times of maximum determined by eye from the data of Turner *et al.* (2006), and using a period of 693 days. The line shows the best-fit parabola; the curvature, 0.0160 ± 0.184, is not significantly different from zero.

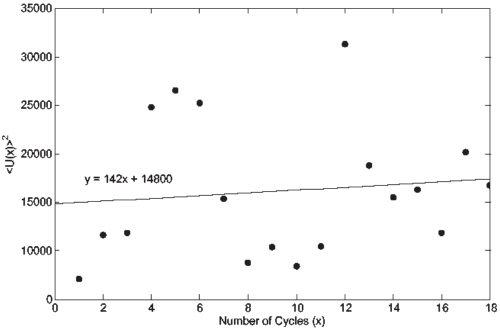

Figure 6. The $<u(x)>^2$ (Eddington and Plakidis 1929) diagram for BC Cyg, based on the (O–C) data shown in Figure 5. The line is the best-fit straight line, but it does not fit the data very well. The nominal slope corresponds to an average cycle-to-cycle fluctuation of 12 days but, as noted in the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

HD 208238 as a δ Scuti Variable Star

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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° 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 ± 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 Hγ; 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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Table 1. HD 208238 observations summary.

UT Date	*HJD Range*	*Mean Differential Error* ΔV	ΔR
2008 July 24	2454671.6990–.8731	0.00245	0.00234
2008 August 3	2454681.6369–.7646	0.00285	0.00302
2008 August 8	2454686.6335–.9142	0.00327	0.00345
2008 August 11	2454689.6243–.8629	0.00393	0.00407
2008 August 12	2454690.6187–.8043	0.00370	0.00377

Table 2. Comparison and check stars.

	Designation	*R.A. (2000)*	*Dec. (2000)*	*V* *(NOMAD)**	*R* *(NOMAD)**
Comp	BD+13 4805	$21^h\ 54^m\ 40.1^s$	+14° 37' 06.3"	10.90	10.61
Check	TYC 1134-0876-1	$21^h\ 54^m\ 57.7^s$	+14° 27' 37.8"	11.77	11.30

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

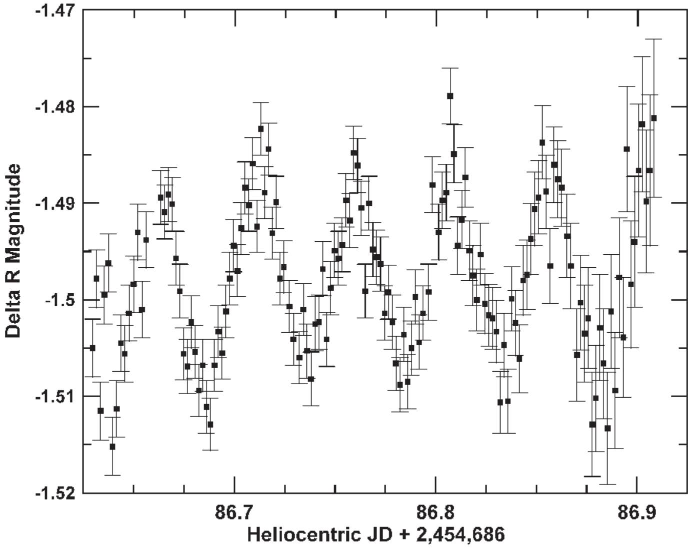

Figure 1a. ΔR magnitudes of HD 208238 on the night of 2008 August 8 (UT).

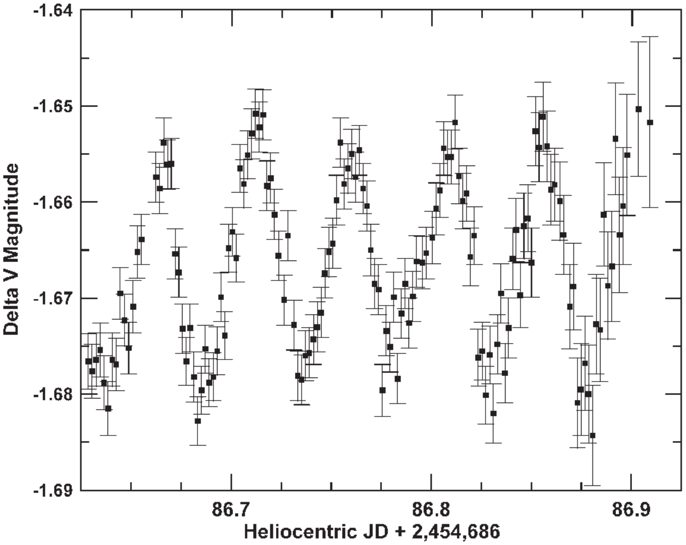

Figure 1b. Δ*V* magnitudes of HD 208238 on the night of 2008 August 8 (UT).

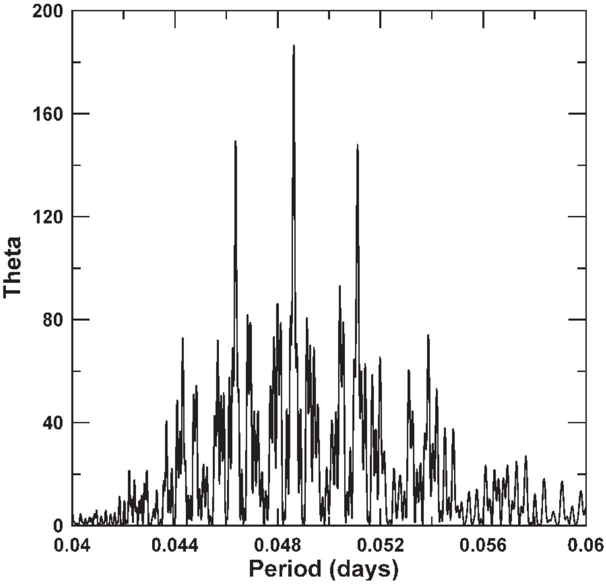

Figure 2. The power spectrum analysis of the differential *V* magnitudes of HD 208238.

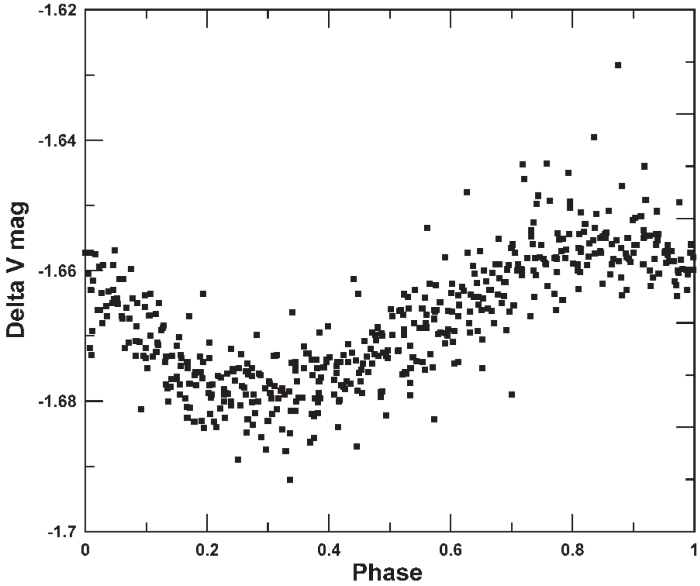

Figure 3. The differential *V* magnitudes of HD 208238 phased on the determined period.

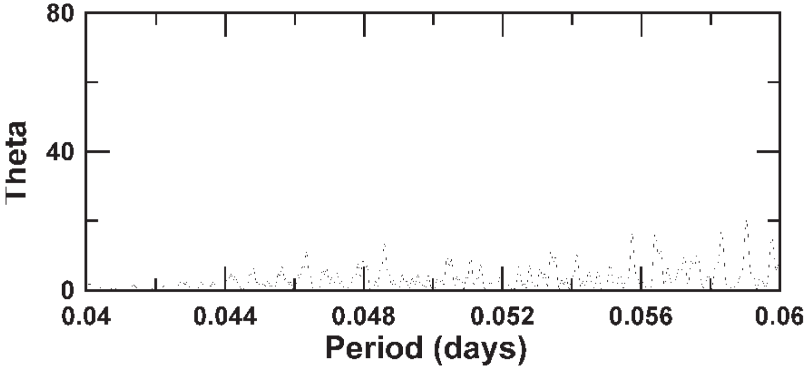

Figure 4. Results of period-searching the *V* data after removing the 0.048622-day period.

The Light Curve of SU Carinae

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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° 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

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 ~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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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° 53' 09.5").

Chart Nr. 284/1105	*mag.*	*R.A. (2000)* *h*	*m*	*s*	*Dec.* °	'	"	V	B–V	*S*	*HD/DM*
a	82	10	11	32.54	–61	14	23.3	8.12	+0.56	HIP	88663
c	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
l	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	
o	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
p	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 Photometry								V	*Err*		
u		10	13	13.93	–60	52	38.4	12.68	0.08		

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.*

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

Label	*R.A. (2000)* *h*	*m*	*s*	*Dec. (2000)* °	′	″	V	*Err*	*Source*
u127	10	13	13.93	–60	52	38.4	12.68	0.04	ASAS-3
v135	10	13	21.08	–60	53	33.3	13.54	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 red?

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.).*

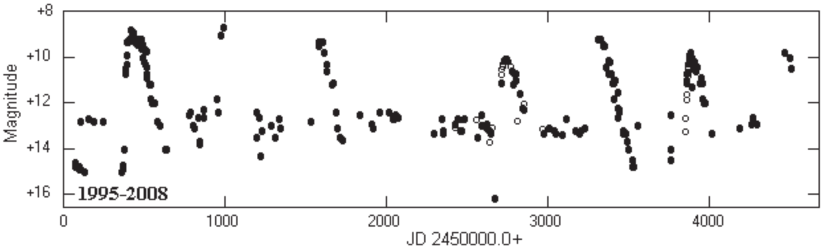

Figure 1. An excerpt of the AAVSO and RASNZ data (dots) and ASAS data (circles) on SU Car.

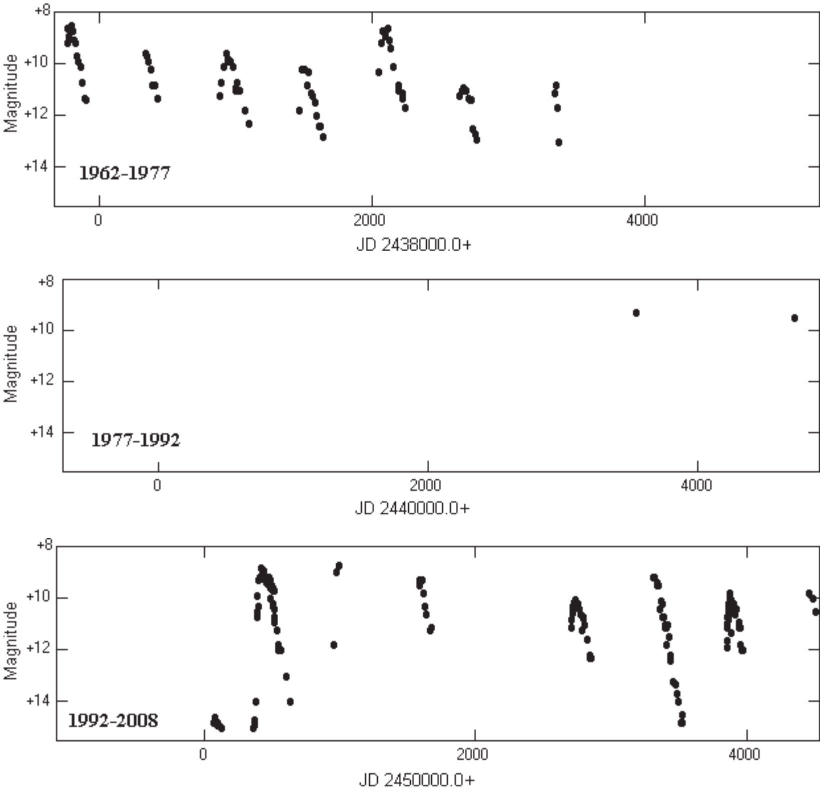

Figure 2. The reviewed light curve of SU Car.

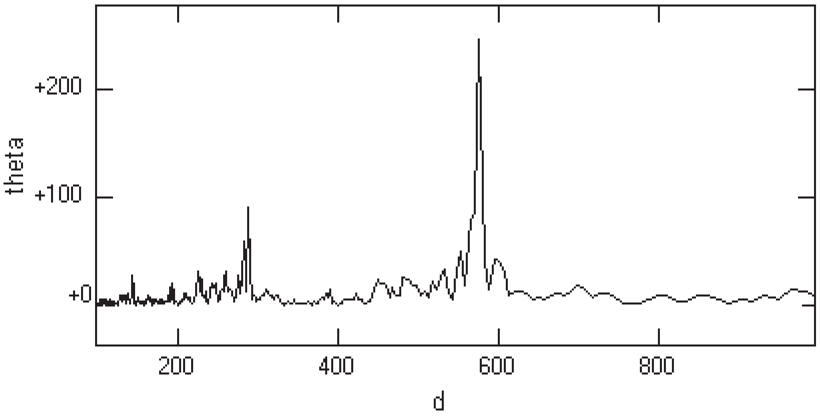

Figure 3. The periodogram of SU Car, showing 575.3740 days.

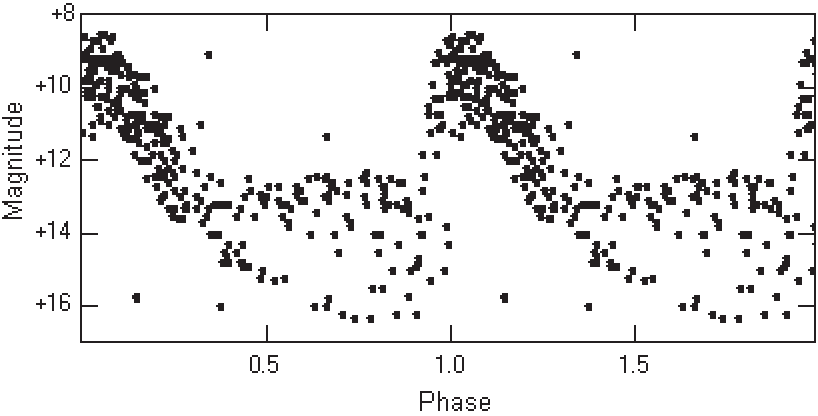

Figure 4(a) The phase diagram of SU Car from the full data set.

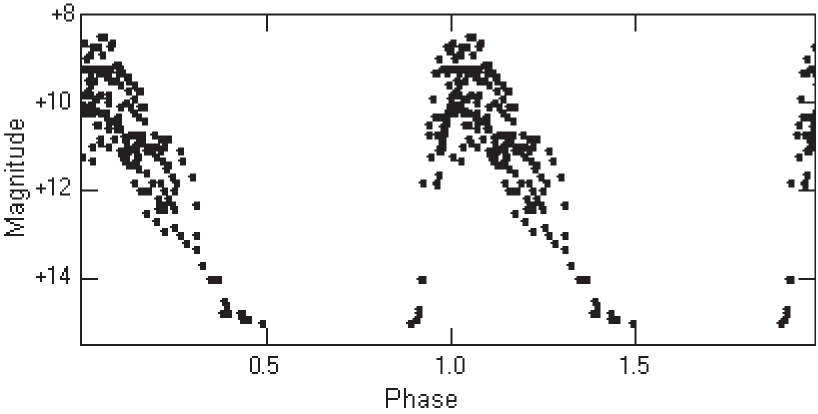

Figure 4(b) The phase diagram of SU Car from the edited data set of Figure 2. The scatter in the brighter part of the curve is from a combination of sources. Many more observers have contributed to this part of the curve, each with their inherent scatter, and every maximum is a different peak brightness.

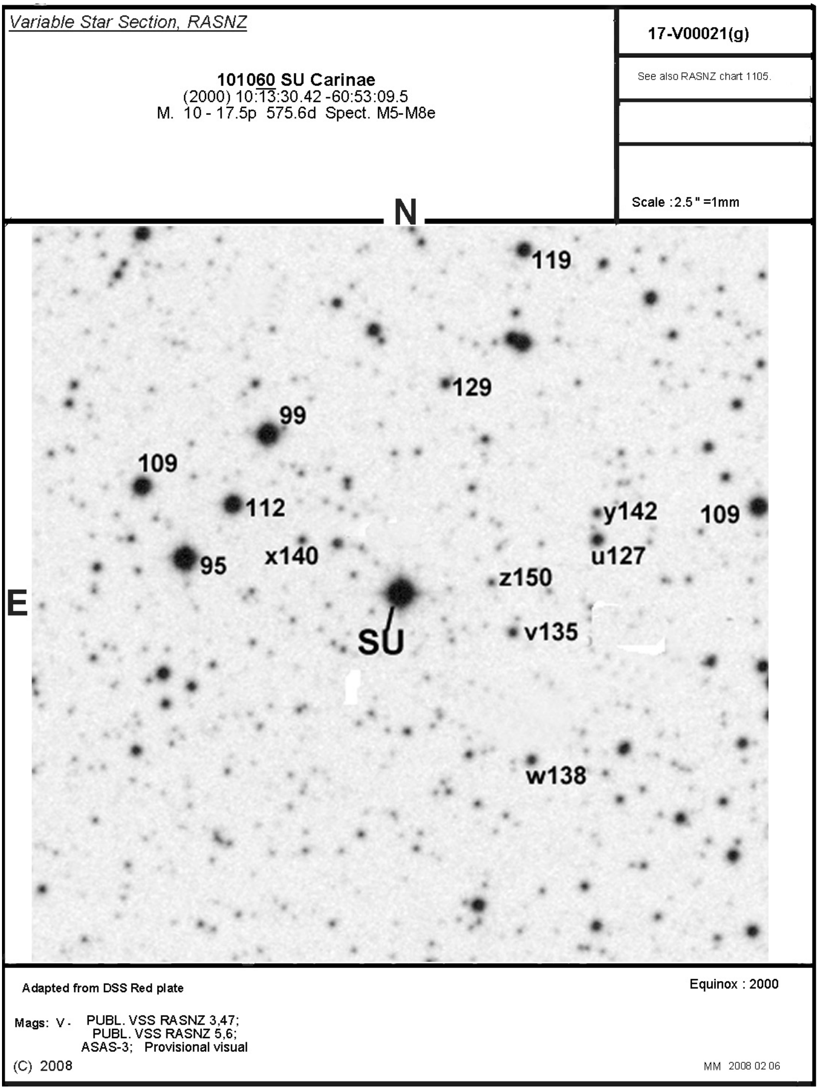

Figure 5. The “g” scale chart for SU Car (previously unpublished). Height of field = 7.5'. Comparison star data are in Table 1.

Recent Minima of 155 Eclipsing Binary Stars

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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:

$$\begin{aligned} \text{Min(JD)} = 2451978.7504 &+ 0.867216691\ \text{E} \\ \pm 0.0004 &\pm 0.00000024 \end{aligned}$$

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:

$$\begin{aligned} \text{Min (JD)} = 2451978.7504 &+ 0.867216691\ \text{E} \\ \pm 0.0004\ &\pm 0.00000024 \end{aligned} \tag{1}$$

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 the AAVSO eclipsing binary program.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
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

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
CZ Aqr	54452.6427	12844	–0.0387	60	CCD	J. Bialozynski	0.0001
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	90	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

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*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	66	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	97	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 continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
XZ CMi	54513.7296	20852	–0.0078	57	CCD	K. Menzies	0.0002
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 continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
IR Cas	54380.8845	17654	0.0104	47	CCD	G. Samolyk	0.0002
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	66	CCD	G. Samolyk	0.0001
EG Cep	54429.5738	21731	0.0143	58	CCD	G. Samolyk	0.0001

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
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	77	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	77	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 continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*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	99	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

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
WW Gem	54421.7597	22974	0.0328	79	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 continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–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	66	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 continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
GU Ori	54520.5873	24328	–0.0431	127	CCD	G. Samolyk	0.0002
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 continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–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

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
RZ Tau	54488.5830	40445	0.0528	107	CCD	G. Samolyk	0.0001
RZ Tau	54513.5233	40505	0.0526	64	CCD	K. Menzies	0.0001
TY Tau	54520.6348	30935	0.2474	40	CCD	J. Bialozynski	0.0002
AC Tau	54457.7937	4317	0.0358	125	CCD	J. Bialozynski	0.0002
AC Tau	54496.6175	4336	0.0359	30	CCD	J. Bialozynski	0.0009
AM Tau	54397.8894	4474	–0.0525	n/a	CCD	R. Sabo	0.0001
AN Tau	50437.559	13784	–0.027	13	CCD	S. Cook	n/a
AN Tau	54447.4029	16267	0.6660	79	CCD	F. Salvaggio	0.0003
AQ Tau	54498.6820	20432	0.5575	99	CCD	J. Bialozynski	0.0003
CT Tau	54399.8518	13490	–0.0479	94	CCD	J. Bialozynski	0.0002
EQ Tau	54338.8117	41381.5	–0.0254	81	CCD	G. Samolyk	0.0002
EQ Tau	54421.7588	41624.5	–0.0260	60	CCD	J. Bialozynski	0.0001
EQ Tau	54462.5502	41744	–0.0257	91	CCD	G. Samolyk	0.0001
HU Tau	54437.7187	6401	0.0224	119	CCD	J. Bialozynski	0.0003
HU Tau	54509.6881	6436	0.0213	105	CCD	J. Bialozynski	0.0005
V Tri	54435.6628	51198	–0.0036	28	CCD	K. Menzies	0.0001
V Tri	54435.6641	51198	–0.0023	53	CCD	G. Samolyk	0.0001
X Tri	54380.6403	12226	–0.0701	95	CCD	G. Samolyk	0.0001
X Tri	54411.7288	12258	–0.0707	80	CCD	J. Bialozynski	0.0002
X Tri	54448.6473	12296	–0.0705	71	CCD	G. Samolyk	0.0001

Table continued on following page

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
RS Tri	54387.7467	8616	–0.0273	55	CCD	J. Bialozynski	0.0001
RS Tri	54452.6495	8650	–0.0279	78	CCD	J. Bialozynski	0.0001
RV Tri	54448.7214	11166	–0.0265	75	CCD	J. Bialozynski	0.0002
RV Tri	54491.6789	11223	–0.0280	34	CCD	E. Wiley	0.0005
RV Tri	54513.5351	11252	–0.0281	82	CCD	G. Samolyk	0.0002
W UMa	54405.8949	25897	–0.0537	76	CCD	G. Samolyk	0.0007
W UMa	54524.6648	26253	–0.0587	n/a	CCD	J. Bialozynski	0.0002
TY UMa	54505.8002	42232.5	0.2523	41	CCD	K. Menzies	0.0003
TY UMa	54521.5787	42277	0.2538	96	CCD	G. Samolyk	0.0003
UX UMa	54505.8560	86810	0.0018	33	CCD	K. Menzies	0.0001
UX UMa	54519.8194	86881	0.0015	50	CCD	G. Samolyk	0.0001
XZ UMa	54493.5538	6811	–0.0937	96	CCD	G. Samolyk	0.0001
XZ UMa	54521.6669	6834	–0.0940	60	CCD	J. Bialozynski	0.0001
AF UMa	54514.7606	5272	0.5306	160	CCD	J. Bialozynski	0.0002
AW Vul	54380.6128	10038	–0.0115	88	CCD	G. Samolyk	0.0001
AY Vul	54385.6722	4850	–0.0718	78	CCD	J. Bialozynski	0.0002
BE Vul	54388.6973	9199	0.0635	100	CCD	J. Bialozynski	0.0002
BE Vul	54399.5580	9206	0.0599	97	CCD	G. Samolyk	0.0001
BT Vul	54366.6433	16618	0.0017	108	CCD	G. Samolyk	0.0002
BU Vul	54382.7400	36642	0.0155	59	CCD	J. Bialozynski	0.0001
CD Vul	54338.6624	11759	–0.0001	79	CCD	G. Samolyk	0.0001

Recent Minima of 184 Eclipsing Binary Stars

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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 minima of stars in the AAVSO eclipsing binary program.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*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	90	CCD	G. Samolyk	0.0003
KP Aql	54630.8161	4227	–0.0113	80	CCD	J. Bialozynski	0.0002
OO Aql	54596.8635	31539	0.0394	80	CCD	G. Samolyk	0.0001

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
OO Aql	54639.6886	31623.5	0.0409	80	CCD	K. Menzies	0.0002
OO Aql	54668.8275	31681	0.0395	50	CCD	R. Sabo	0.0003
OO 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
TY Boo	54533.7584	63230	0.0843	54	CCD	G. Samolyk	0.0003

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
TY Boo	54556.7534	63302.5	0.0861	60	CCD	J. Bialozynski	0.0004
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
TY Boo	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	77	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

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min)* *2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard 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
TY Cap	54680.7973	6946	0.0630	86	CCD	G. Samolyk	0.0004

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*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

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard 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	77	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	77	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 Cet	54702.8526	38912.5	–0.0250	78	CCD	G. Samolyk	0.0002

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
RW Com	54570.7514	61296	–0.0192	60	CCD	J. Bialozynski	0.0001
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	77	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 continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–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

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*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 continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–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	77	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

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
RZ Dra	54709.7581	19119	0.0464	72	CCD	G. Samolyk	0.0002
TW Dra	54622.7107	3736	0.0353	90	CCD	J. Bialozynski	0.0002
TW Dra	54636.7442	3741	0.0346	154	CCD	G. Samolyk	0.0001
TW Dra	54681.6530	3757	0.0338	105	CCD	G. Samolyk	0.0002
UZ Dra	54600.8200	3995.5	0.0033	42	CCD	K. Menzies	0.0004
UZ Dra	54613.8642	3999.5	0.0023	98	CCD	K. Menzies	0.0002
UZ Dra	54618.7594	4001	0.0055	100	CCD	J. Bialozynski	0.0001
BH Dra	54626.7592	8038	–0.0026	100	CCD	J. Bialozynski	0.0003
RX Her	54621.7598	12061	0.0001	98	CCD	J. Bialozynski	0.0007
RX Her	54678.6730	12093	–0.0010	132	CCD	G. Samolyk	0.0003
RX Her	54703.5726	12107	–0.0014	209	CCD	K. Menzies	0.0001
SZ Her	54562.8069	15522	–0.0198	66	CCD	G. Samolyk	0.0001
SZ Her	54573.4414	15535	–0.0205		CCD	J. Virtanen	0.0001
SZ Her	54589.8040	15555	–0.0199	79	CCD	J. Bialozynski	0.0001
SZ Her	54616.8016	15588	–0.0196	57	CCD	E. Wiley	0.0001
TT Her	54592.7991	16004	0.0354	80	CCD	J. Bialozynski	0.0003
TT Her	54708.6334	16131	0.0362	81	CCD	G. Samolyk	0.0001
TU Her	54627.7704	4661	–0.1809	100	CCD	J. Bialozynski	0.0001
TU Her	54652.7066	4672	–0.1817	125	CCD	G. Samolyk	0.0001
TU Her	54702.5792	4694	–0.1831	35	CCD	K. Menzies	0.0002

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–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	66	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	77	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

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
SW Lac	54676.6986	29313.5	–0.1012	80	CCD	G. Samolyk	0.0002
SW Lac	54703.7992	29398	–0.1015	144	CCD	K. Menzies	0.0001
VX Lac	54681.8447	8770	0.0646	51	CCD	G. Samolyk	0.0002
VX Lac	54707.6330	8794	0.0650	90	CCD	K. Menzies	0.0001
CM Lac	54652.6832	17216	–0.0034	85	CCD	G. Samolyk	0.0002
CO Lac	54680.7854	17602.5	0.0051	90	CCD	G. Samolyk	0.0006
DG Lac	54674.6726	4607	–0.2165	68	CCD	G. Samolyk	0.0004
Y Leo	54534.6425	5396	–0.0149	57	CCD	G. Samolyk	0.0001
UU Leo	54533.7225	5439	0.1557	73	CCD	G. Samolyk	0.0003
UV Leo	54583.6381	26901	0.0311	94	CCD	G. Samolyk	0.0001
UV Leo	54631.6446	26981	0.0308	51	CCD	G. Samolyk	0.0003
VZ Leo	54529.6543	21438	–0.0665	80	CCD	J. Bialozynski	0.0002
VZ Leo	54590.6862	21494	–0.0694	89	CCD	G. Samolyk	0.0003
T LMi	54562.6170	3035	–0.1020	88	CCD	H. Gerner	0.0002
T LMi	54574.6994	3039	–0.0991	105	CCD	J. Bialozynski	0.0002
T LMi	54583.7589	3042	–0.0993	88	CCD	G. Samolyk	0.0002
Z Lep	54545.6061	27293	–0.1684	75	CCD	G. Samolyk	0.0002
SS Lib	54583.8077	9338	0.1196	100	CCD	G. Samolyk	0.0005
SS Lib	54596.7495	9347	0.1194	108	CCD	J. Bialozynski	0.0002
UZ Lyr	54596.8841	5767	–0.0271	78	CCD	G. Samolyk	0.0004

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
UZ Lyr	54632.8188	5786	–0.0265	99	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	77	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	97	CCD	G. Samolyk	0.0002
EP Mon	54532.5803	18852	0.0363	97	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 continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
V1010 Oph	54614.7722	23702	–0.1189	80	CCD	J. Bialozynski	0.0012
FL Ori	54499.7789	5901	0.0350	65	CCD	J. Bialozynski	0.0001
FZ Ori	54531.6460	26269	–0.0603	58	CCD	J. Bialozynski	0.0003
GU Ori	54526.7072	24341	–0.0420	80	CCD	J. Bialozynski	0.0003
U Peg	54706.8073	48549	–0.1250	121	CCD	K. Menzies	0.0001
TY Peg	54709.7014	4611	–0.3090	149	CCD	G. Samolyk	0.0001
BB Peg	54631.8082	30062	–0.0013	64	CCD	G. Samolyk	0.0001
BB Peg	54658.7402	30136.5	–0.0012	91	CCD	K. Menzies	0.0001
BB Peg	54678.8041	30192	–0.0007	80	CCD	G. Samolyk	0.0001
BB Peg	54710.6143	30280	–0.0027	65	CCD	G. Samolyk	0.0003
BG Peg	54698.6872	4695	–1.8512	76	CCD	K. Menzies	0.0007
BX Peg	54650.7799	37285	–0.0868	61	CCD	K. Menzies	0.0001
BX Peg	54702.6579	37470	–0.0866	95	CCD	G. Samolyk	0.0001
DI Peg	54710.6180	13366	–0.0133	83	CCD	G. Samolyk	0.0001
GP Peg	54702.7852	13801	–0.0454	86	CCD	G. Samolyk	0.0002
GP Peg	54706.6890	13805	–0.0441	120	CCD	K. Menzies	0.0001
KW Peg	52240.5777	5000	0.0902	30	CCD	S. Dvorak	0.0003
KW Peg	52602.653	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	53589.6806	6652.5	0.1185	52	CCD	G. Samolyk	0.0007

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*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	77	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

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
RZ Tau	54529.7351	40544	0.0531	59	CCD	J. Bialozynski	0.0002
TY Tau	54533.5631	30947	0.2474	76	CCD	G. Samolyk	0.0002
WY Tau	54537.6920	24735	0.0550	80	CCD	J. Bialozynski	0.0002
EQ Tau	54708.8335	42465.5	–0.0254	75	CCD	G. Samolyk	0.0002
V Tri	54707.7832	51663	–0.0039	104	CCD	K. Menzies	0.0001
X Tri	54680.8430	12535	–0.0717	73	CCD	G. Samolyk	0.0001
W UMa	54547.6861	26322	–0.0584	91	CCD	K. Menzies	0.0001
TX UMa	54558.6990	3121	0.1851	109	CCD	J. Bialozynski	0.0003
TY UMa	54547.6370	42350.5	0.2535	32	CCD	K. Menzies	0.0003
TY UMa	54552.7789	42365	0.2546	60	CCD	J. Bialozynski	0.0001
TY UMa	54553.6647	42367.5	0.2541	55	CCD	J. Bialozynski	0.0001
TY UMa	54561.8173	42390.5	0.2523	87	CCD	G. Samolyk	0.0004
TY UMa	54574.5829	42426.5	0.2545	50	CCD	K. Menzies	0.0001
TY UMa	54600.6427	42500	0.2557	82	CCD	K. Menzies	0.0005
TY UMa	54620.6744	42556.5	0.2560	53	CCD	K. Menzies	0.0002
TY UMa	54681.6542	42728.5	0.2551	52	CCD	G. Samolyk	0.0006
UX UMa	54519.4264	86879	0.0019	83	CCD	J. Virtanen	0.0001
UX UMa	54534.5701	86956	0.0019	48	CCD	G. Samolyk	0.0001
UX UMa	54545.5835	87012	0.0017	40	CCD	G. Samolyk	0.0001
UX UMa	54558.7606	87079	0.0018	12	CCD	J. Bialozynski	0.0002

Table continued on following pages

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*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
AZ Vir	54554.7638	30252.5	–0.0199	94	CCD	J. Bialozynski	0.0002

Table continued on following page

Table 1. Times of minima of stars in the AAVSO eclipsing binary program, cont.

Star	*HJD(min) 2400000+*	*Cycle*	*O–C*	*N*	*Type*	*Observer*	*Standard Error*
AZ Vir	54610.7099	30412.5	–0.0203	77	CCD	G. Samolyk	0.0002
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	97	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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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 1σ and do not indicate any statistically significant variation between the epochs, in agreement with the findings of Pardo and Poretti (1997). The values are also consistent with the values 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 *f*0 and *f*1 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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Table 1. AAVSO data sets for TU Cas.

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 2. Frequency analysis results for data set 1.

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
2*f0*	0.93542(3)	0.06(1)	4.5
1–*f1*	0.34138(2)	0.06(1)	4.7
1-day artifact	1.00512(3)	0.06(1)	4.6

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–*f1*	0.34136(6)	0.12(2)	6.0
f0+*f1*	1.12607(9)	0.10(2)	4.9
2*f0*	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
f1	0.65863(2)	0.105(7)	11.2
2*f0*	0.93487(2)	0.097(7)	10.4
f0+*f1*	1.12609(2)	0.069(7)	7.4
2*f0*+*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
2*f0*	0.93492(3)	0.103(7)	11.7
f0+*f1*	1.12612(4)	0.078(7)	8.9
2*f0*+*f1*	1.59354(5)	0.053(7)	6.0
1-day artifact	1.00191(5)	0.055(7)	6.2
3*f0*	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
f0 alias	1.46980(7)	0.039(7)	4.4

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

Frequency ID	*Frequency (c/d)*	*Amplitude (V mag)*	*SNR*
f0	0.467448(2)	0.229(9)	40.5
f1	0.658655(2)	0.10 (5)	18.1
2*f0*	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
f1 lobe	0.65868 (2)	0.05 (5)	8.8
?	0.000170(3)	0.048(6)	8.6
2*f0*+*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
3*f0*	1.402312(5)	0.030(4)	5.4
f0–*f1*	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*f0*	2.525188(6)	0.024(4)	4.2
1-month artifact	0.032680(6)	0.022(4)	4.0
4*f0*	2.525188(6)	0.024(4)	4.2

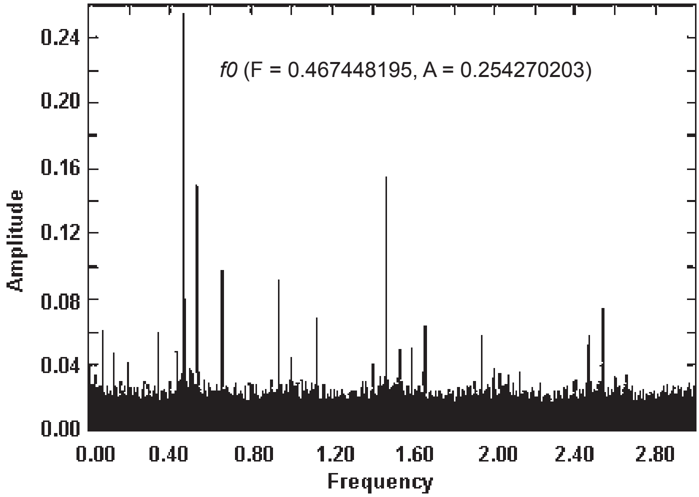

Figure 1. The initial Fourier spectrum for the combined data set, prior to prewhitening steps. Frequencies *f0*, *f1*, and their multiples and cross-terms are readily apparent, as well as several aliases and sampling artifacts.

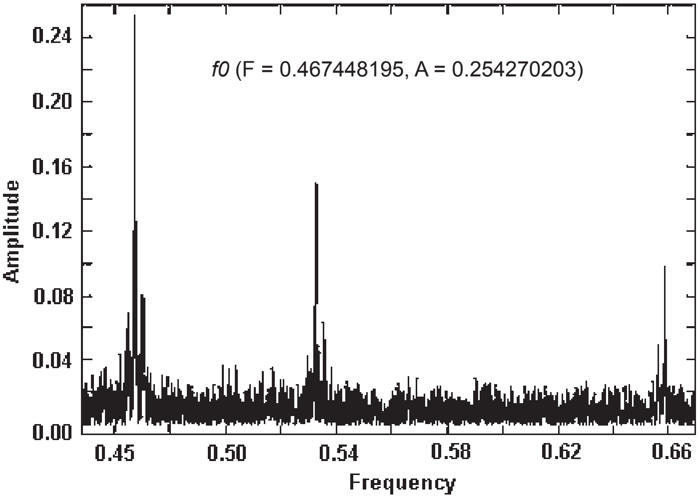

Figure 2. An enlarged view of the initial Fourier spectrum for the combined data set showing the region around *f0* and *f1*.

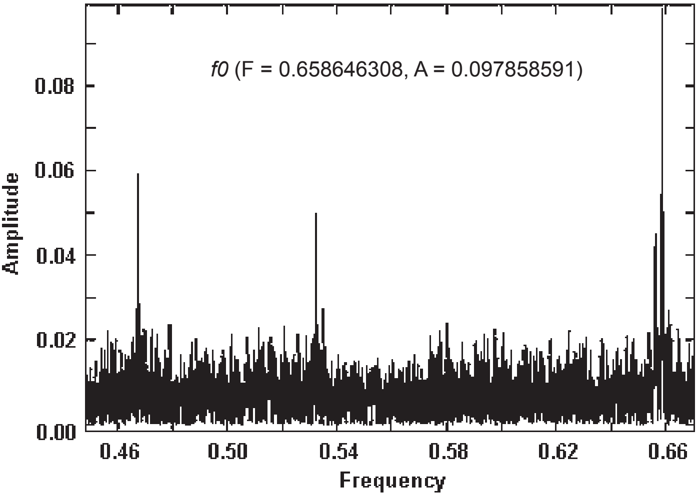

Figure 3. The same enlarged view as Figure 2, after prewhitening with the primary frequency found for *f0*. Note the residual signal from *f0* that remains, near 0.46 cd^{-1}.

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 yet 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

Matthew M. Beaky
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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

Gerald P. Dyck
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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 week-long "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**

Donna L. Young
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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

Mary Ann Kadooka
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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
295 Salem Street, Woburn, MA 01801

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)."

Index to Volume 36

Author

Subject

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

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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:

$$\text{“}M_v = -7.92 - 0.81 \arctan\{(1.32 - \log(t_2))/0.23\} \qquad (2)\text{”.}$$

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:

$$A_v = a_v \times D \qquad (4)$$

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

NOTES