Observations and Analysis of Three RR Lyrae Stars

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Abstract

Among the areas of astronomical research most open and suited to the backyard astronomer, that of variable stars probably provides the most variety and work. With thousands of variables within reach that are only poorly understood, there is no want for research projects. While most work at the Palmer Divide Observatory is dedicated to asteroid photometry, from time-to-time variable stars make it to the observing list. In this paper, three “full moon project” variables are presented, all intrinsic variables of type RR Lyrae. The estimated period and amplitude is provided along with multi-color data in some cases. Also discussed will be how to derive sequences for fields were no photometry is available from the AAVSO as well as submitting data to the AAVSO using the recently-adopted format for CCD observers.

1. Introduction

I’ve been interested in variable stars for many years. However, most of my work is in the field of asteroid photometry, including finding lightcurve period and amplitude, absolute magnitude and phase slope parameter, and – most recently – spin axis and shape modeling. In order to extend the sample of asteroids, most targets are 15th magnitude and fainter, meaning that near the time of full moon, most targets are too faint to work with sufficient signal-to-noise (SNR). Since photons are a terrible thing to waste, if the weather allows, some of the telescopes at the PDO are aimed at moderately bright (10-14th magnitude) variable stars. Since time is limited – a few days either side of full moon – the selected targets are those with known periods on the order of 0.3-0.6d. This way, all or most of a cycle can be captured in one or two nights and so make a complete curve. I do check with resources on the web such as the AAVSO’s International Variable Star Database (HTTP), the AAVSO’s data base (HTTP), and the IBVS (HTTP) to locate variables where complete curves are scarce or non-existent, that haven’t been worked for some time, or just might be interesting. In particular, I try to find at least one eclipsing binary of the W UMa type (contact binaries) since those were what sparked my interest in variable stars.

During the period of 2007 October through 2008 March, I obtained complete, or very nearly so, lightcurves for seven variable stars and partial curves on about as many more. Results on those thereof those more thoroughly-covered stars are presented in this paper.

2. Equipment and Software

The Palmer Divide Observatory is located north of Colorado Springs, CO, at 2300 m elevation. Four telescopes are housed in two buildings. A 0.5 m Ritchey-Chretien equipped with an SBIG STL-1001E occupies one building while three 0.35 m LX-200 GPS telescopes with various cameras occupy the second. Each telescope/camera combination is controlled by a separate computer, all of which are on a local network (LAN) that extends into the author’s home about 25 m from the observatory buildings, and are monitored via remote desktop software (RAdmin). *MPO Connections* (Bdw Publishing 2008) provides scripted control of the telescopes and cameras to the point where I can watch TV or go to bed and have the images on the office computer when I get up. The images are processed and measured in *MPO Canopus* (Bdw Publishing 2008), which also includes the FALC Fourier analysis algorithm by Harris (1989). This works in most cases but, for some variables, other analysis packages would probably be better suited to the task. Modeling of eclipsing binary stars is done with David Bradstreet’s *Binary Maker 3* (Contact Software 2008).

3. Program Description

The first step is to determine which variable to work. Some of the considerations made when picking a new target are:

- The star must be near the eastern horizon at the end twilight (~30° altitude or more). This allows for the longest possible run. Depending on the star’s declination and time of year, this means an observing session of between 6 and 11 hours.

- The type of variable is usually RR(ab) Lyr or W UMa. These tend to have shorter periods and so can be covered in a single run. Furthermore, both have particularly interesting lightcurves. The W UMa stars can also be modeled with Binary Maker 3, providing an even higher return on the investment of observing time.
- The star must be bright enough through the cycle to be readily worked with a V or R filter. For variable observations of these types of objects, filtered data is strongly preferred. If nothing else, it makes for easier standardization for direct comparison to data from other observers. At PDO, this consideration means the star must stay above mag. 15 V to get an SNR of at least 100 (~ 0.01 mag precision) with 3-minute exposures.
- If possible, photometry for field stars should be available. A visit to the Variable Star Plotter on the AAVSO site (HTTP) quickly shows if this is the case. This is not, however, a critical requirement. If necessary, I develop my own sequences as described later on.
- The star should not be "over-observed." It's a sad fact that some stars are saturated by observes while hundreds of others just as interesting or challenging are hardly observed. Even if so, it's not uncommon that an observer gets a few data points and moves on. For a long period variable (LPV), this is fine but for stars with short periods or that show rapid, very short changes ("flickering"), this is not good. Quantity is sometimes stressed over quality, but it's possible to make quality work by providing a high quantity of data on a single target just as much as it is by providing a few data points on a quantity of targets.

Once a target is selected a script is written that will take the necessary images. Usually this means taking a continuous series of at least V or R images, but often alternating V/R, for as long as the star is above 30° altitude and between end of evening twilight to start of morning twilight. Two color observations are important for finding the average color index used when reducing the data to a standard system or modeling in *Binary Maker 3*. They also show how the stars behave in different colors, which can reveal significant information about their structure. For example, the RRab Lyr stars change color over the course of their cycle, having a minimum color difference at maximum (see Figure X). In eclipsing systems, two color observations can help reveal the presence of hot or dark spots on one or both stars, thus helping with modeling. "More Data!" is often said when working asteroid lightcurves. The same applies for almost any field of research. The more information one can acquire on a variable star, the better chance he has of understating its true nature.

3.1 Program Description: Quick Sequences

A sequence of calibrated comparison stars is not always available for a selected star. This should not be a deterrent to working it. The AAVSO team can do only so much and while new sequences are being made and many more updated and to be released in the near future, the stars wait for no man. It's not that hard to get a good *initial* sequence for a target field, one that allows you to make reasonable color index corrections and get your measurements on a standard system. That system may not match *the* standard Johnson-Cousins system (BVRcIc), but with care, the transition between the two will be a simple linear function or, even better, constant offset.

For those not familiar, *color index* is the difference in magnitudes for an object when measured in two different colors. The most common color indices are B-V, V-R, and V-I. So, for example, a star that is found to be B = 14.500 and V = 14.000 has a B-V color index of 0.500 (14.500 – 14.000).

A word of caution: the technique about to be described is sometimes called "all-sky photometry." You've probably heard bad things about that, and for good reason. It does require considerable care and attention to details. It is *not* for the beginner photometrist. However, it's far from impossible and, there are some things you can do to simplify the process and still keep errors under control.

The goal here is to establish an *initial* sequence so that you can have more flexibility in choosing comparisons by being able to account for color index differences. I prefer to do this over the "Simplified Differential Photometry" approach described below and that has been used so successfully for many years. While that approach has served well, the more you can do to improve the accuracy of your data, the better science will be served.

3.1.1. Quick Sequences: The Method

To get a good initial sequence, you first need to determine the transforms for your system. Transforms are a set of equations, easily determined, that convert magnitudes on your system to a standard system, usually Johnson-Cousins. I won't go into details here but instead refer you to my book, *A Practical Guide to Lightcurve Photometry and Analysis*, or to *Astronomical Photometry* by Henden and Kaitchuck.

In short, you shoot a reference field, one with well-calibrated magnitudes (M67 is a good example) in two or more filters. Do the same for the variable star field. Using the images from the reference field, you can find the transforms for you system. When those transforms are applied to the measurements for the variable star field, you can derive calibrated "standard" magnitudes for the selected comparison stars as well as correct for color differences between the variable and comparisons. This can significantly improve the accuracy of your measurements. Again, your magnitudes may not be the same as when a higher quality sequence is found, but if you've been careful, then your data will probably require only a simple constant offset to make them match the magnitudes based on the new sequence.

3.1.2. Simplified Differential Photometry

If you're not comfortable trying to generate your own sequence, do not let this stop you. Instead, make your observations in a standard filter, usually V, and do the simple reductions where you simply take the different in instrumental magnitudes between a target and a comparison and add that to the known (or assumed) magnitude of the comparison. For example, for any given filter

$$\Delta m = (m_v - m_c) \qquad (1)$$

$$Mv = Mc + \Delta m \qquad (2)$$

Where m_v = instrumental magnitude of variable (not v for visual)
m_c = instrumental magnitude of comparison
Mv = reduced magnitude of the variable
Mc = known (assumed) magnitude of the comparison

This technique has been used for years and serves quite well. It does not allow for color differences, i.e., the variable and comparison have different color indices, which shows why it's a good idea to use comparison stars of similar color to the variable. This is not always possible and if a star changes color significantly over its cycle, you're forced to use an average value or attempt the more difficult task of using a different color index value for each observation or at least group of observations.

4. Data Reduction

All images were processed with dark frames and flat fields in *MPO Canopus* using the *PhotoRed* (Photometric Reductions) utility. Once the system transforms were found and, if necessary, comparison star sequences were determined, the processing was mostly automatic.

- A "batch reference file" was created. This is simple text file that gives data for one or more comparisons, a check star for ensemble photometry under the new AAVSO guidelines, and the variable itself. Each line for the comps and check contains the RA/Declination, BVRcIc magnitudes, and a selected color index (usually V-R for my work). The only important data in the line for the variable gives the RA/Declination and color index.
- The Batch Photometry form is then used to tell the program which images to measure and some specific default data to be included in the data files.
- Once the processing begins, each image is automatically measured by finding the plate constants that convert X/Y coordinates to RA/Declination and vice versa. Using the data in the batch reference file, the program is able to find the comparisons, check, and variable and store instrumental magnitude and SNR.
- The final step is to perform ensemble photometry, including transforms if desired, and store the final results in one of two data tables.

The Batch Photometry form is not restricted to measuring data from a single star on a single night. One could have images of multiple targets over several nights and the program will measure them all in a single pass, all without human intervention. This is quite a relief when there are hundreds of images to measure. The downside to this is, of course, that program will try to measure any image, no matter how bad (blank due to clouds, bad tracking, etc.). In lieu of previewing every image, one can simply plot the final data and eliminate (or determine the cause) any bad data points before generating the final report.

4.1 Data Reduction: Ensemble Photometry

Ensemble photometry is accomplished by deriving the magnitude of the variable using one comparison star at a time. If selected, this includes correction for first order extinction and color differences by applying the transforms found previously. The final reduced magnitude is the arithmetic mean of those individual reduced magnitudes. This is done so that the color difference between each comparison and the variable can be taken into separate account. If one just used the simple arithmetic mean of the comparison magnitudes (or, more appropriately, the flux values) and used that to form a differential magnitude, i.e., m_v - m_{cavg}, that would introduce errors if the comparisons and variable were of different colors.

The error is a bit more complex. It is the standard deviation of the arithmetic mean added in quadrature with the 1.0857/SNR errors of the individual comparisons and variable. While not fully correct by any means, this at least does not underestimate the errors.

4.2 Data Reduction: Reports and Submission

PhotoRed generates several different reports based on data from the automated processing, one of which is fully-compatible with the AAVSO's newly adopted CCD observations submission format (Figure 1). Each report can contain data from a single star on a single night or multiple stars on multiple nights. However, it's better to break out the reports by at least individual stars in order to keep the file size manageable. If nothing else, if there is a problem with a given file, this has an impact on the least amount of data.

Another report generates files that are compatible with MPO Canopus and can be imported into that program for period analysis and plotting. The plots in this paper were generated by this method.

5. Three RR Lyrae Stars

The three variable stars presented in this paper are of type RR Lyrae, sometimes called "cluster variables" since they are often found in globular clusters. Specifically, all three are of type RRab, a subgroup that shows a very rapid rise from minimum to maximum and then a much longer descent to the next minimum. A detailed description of these variables is beyond the scope of this paper. Suffice it to say these are *intrinsic variable stars*, meaning that the cause for their variability is due to internal forces, e.g., pulsations, rather than external such as in a binary system with eclipses. See the References section for excellent books on this topic. In particular, I recommend John Percy's *Understanding Variable Stars* (more technical) and Gerry A. Good's *Observing Variable Stars*.

Finder charts indicating the comparison and check stars are located at the end of this paper. These are from the AAVSO's Variable Star Plotter and used here with permission.

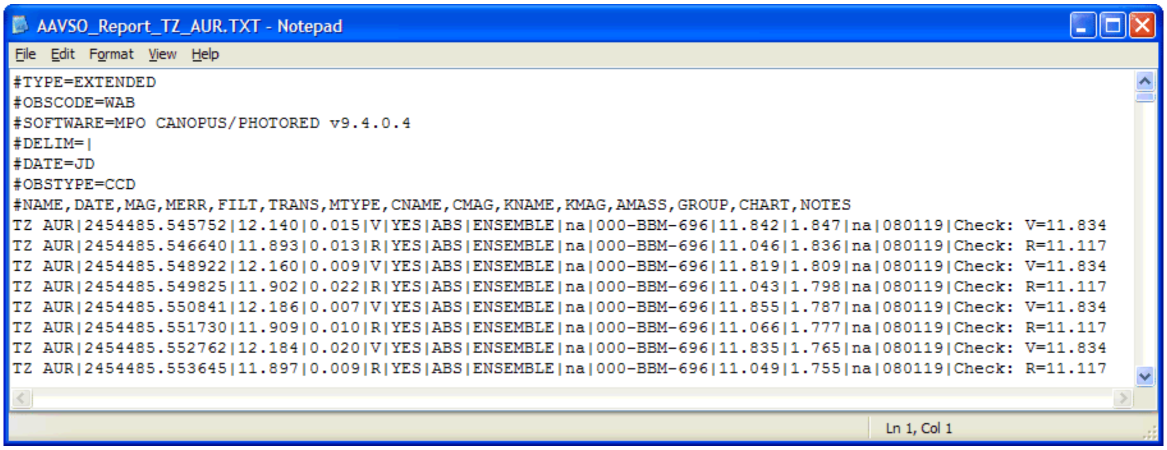

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Figure 1. Sample of the new AAVSO CCD observations format.

5.1 ET PER

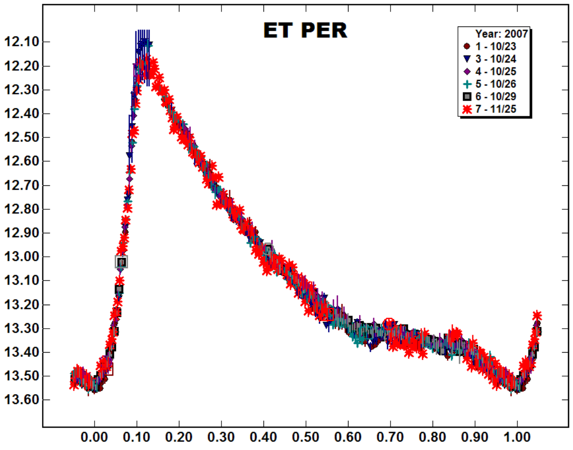


Figure 2. ET PER, V observations.

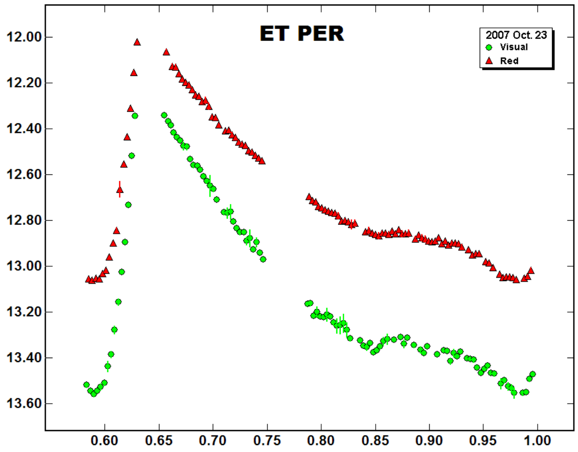


Figure 3. ET PER, V and R observations from 2007 October 23.

No AAVSO sequence was available for this field, so I created my own. The magnitudes and color indices are shown in Table 1.

Sodor et al (2007) found a period of 0.3940135 d based on data from 8 nights from JD 2453988 to 2454171 (2006 Sept. 10 – 2007 Mar. 11). I observed the star from 2007 October 23 – November 25. All observations, except on 2007 October 23, were in V only. V and R data were obtained on 2007 October 23, which shows a striking difference in amplitude in the two colors (Figure 3), which was shown as well by Sodar et al. The V amplitude ranged from 12.21 to 13.53. No maximum was caught in R, so the amplitude range in that band cannot be given.

Typical of the RRab Lyrae stars, there is a rapid increase from minimum to maximum, followed by a slow decline to the next minimum. In some cases, there is a “bump” as the curve approaches minimum light. This is believed to be due to shock waves (“bounces”) within the star (Percy 2007).

Times of *maximum* (HJD) were found for two dates using the method of Hertzsprung as described by Henden and Kaitchuck (1990). Table 2 shows these times as well as those found in different issues of the IBVS and the GCVS. The times of minimum using the General Catalog of Variable Stars (GCVS, Kholopov, P.N., *et al*, 1985) ephemeris were calculated and compared against those from the IBVS and this paper. Figure 4 shows the O-C values based on the GCVS ephemeris. The trend line for the data is essentially flat, especially if the data for Auger are removed from the solution. This would indicate that the period is not evolving. Using the latest TOM reported here and the GSVS epoch, a new ephemeris was computed and O-C values were re-calculated. Those are reported in Table 2 as well. The proposed new ephemeris is:

$$T_{\max} = 2454429.735 \pm 0.002\ \text{d} + 0.39401444 \pm 0.00000002\ \text{d} * E$$

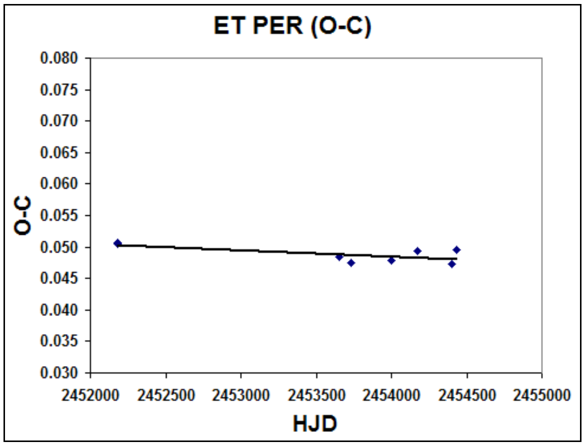


Figure 4. ET PER, O-C values.

	ID (2MASS)	RA	Dec	V	R	V-R	Chart ID
Variable	ET PER	01 39 22.15	+53 52 18.8			0.486	
Comp	J01393818+5355304	01 39 38.19	+53 55 30.5	13.352	12.871	0.481	A
Comp	J01391547+5352478	01 39 15.47	+53 52 47.9	11.746	11.519	0.227	C
Check	J01385791+5352515	01 38 57.92	+53 52 51.6	12.319	11.938	0.381	B

Table 1. Comparison and check stars for ET PER.

Source	T_{max} (Reported)	Period (d)	Cycles	T_{max} (Calc)	O-C_{GCVS} (d)	O-C_{new} (d)
GCVS	2428183.2510	0.39401370				+0.0000000
Agerer	2452179.5240		60902	2452179.473357	+0.050643	–0.0052933
	2452183.4640		60912	2452183.413494	+0.050506	–0.0051488
Hubscher	2453654.3150		64645	2453654.266637	+0.048363	–0.0002270
Sodor	2453733.9048		64847	2453733.857404	+0.047396	+0.0008908
	2454000.2585		65523	2454000.210665	+0.047835	+0.0009554
	2454171.2620		65957	2454171.212611	+0.049389	–0.0002757
Warner	2454399.7878		66537	2454399.740557	+0.047243	+0.0023022
	2454429.7352		66613	2454429.685598	+0.049602	+0.0000000
SPAN	2454429.7352		66613	0.39401444	-0.00000074	

Table 2. Times of maximum for ET PER. Column 2 gives the HJD (heliocentric-corrected Julian Date) for the time of maximum as reported by the source given in column 1. The GCVS HJD is T_0, i.e., the zero point for O-C calculations. The GCVS period is given in column 2. This was used to compute the O-C values. Column 3 gives the number of cycles from T_0 to T_{max} assuming the GCVS period. Column 4 gives the nearest whole number of cycles between T_0 and T_{max} using the GCVS period. Column 5 gives the predicted T_{max} using the GCVS ephemeris and number of cycles in Column 4. Column 5 is the difference, in days, between the HJD in columns 2 and 5, i.e., HJD_2 – HJD_5. The last row gives the HJD that yields the largest T_0-T_{max}, the number of cycles based on the GCVS period, and the period that results in a zero-residual for (T_0-T_{max}) / $Cycles_{span}$. Column 6 gives the revised O-C values based on the new period. The value to the right of the new period is the difference between periods, i.e., GCVS – New, in days.

5.2 TZ AUR

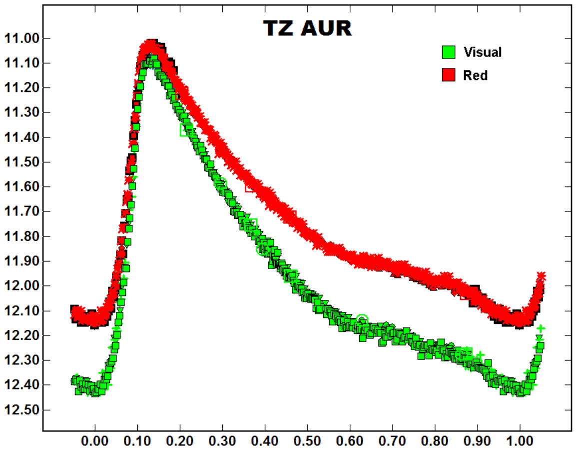


Figure 5. Combined V and R plots of TZ AUR.

This variable was worked on 2008 January 20 and 23-25. V and R images were taken in alternating succession throughout each session. Figure 5 shows the combined data where, once again, the change in color is very apparent. The amplitude in V ranged from V = 11.09 to 12.42. In R, the amplitude range was R = 11.04 to 12.14

The color index goes from V-R ~ 0.05 at maximum (A3, 8700K) to V-R ~ 0.28 at minimum (F7, 6200K). A photometric sequence was available from the AAVSO for this star. Table 3 shows the magnitudes and color indices for the comparison and check stars that were used. Table 4 shows numerous times of minimum found in the IBVS journals along with the GCVS epoch and period and the times of minimum found as a result of this research. See the caption under Table 2 for details about the various columns.

Table 4 shows numerous times of minimum found in the IBVS journals along with the GCVS epoch and period and the times of minimum found as a result of this research. See the caption under Table 2 for details about the various columns.

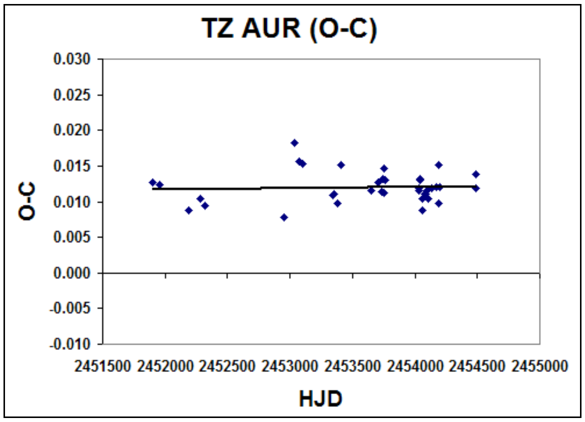


Figure 6. The O-C plot for TZ AUR. See text for details.

Based on the time of maximums found here and analysis of O-C times, a new ephemeris for TZ AUR is:

$$T_{max} = 2454489.6648 \pm 0.002 \text{ d} + 0.39167477 \pm 0.00000002 \text{ d} * E$$

	ID (AAVSO UID)	RA	Dec	V	R	V-R	Chart ID
Variable	TZ PER	07 11 35.00	+40 46 37.0			0.150	
Comp	000-BBM-657	07 11 22.93	+40 43 57.9	12.503	12.117	0.326	125
Comp	000-BBM-684	07 11 59.13	+40 45 42.1	12.677	12.336	0.341	127
Comp	000-BBM-664	07 11 39.06	+40 49 57.6	10.903	10.691	0.212	109
Check	000-BBM-696	07 12 11.76	+40 44 19.6	11.834	11.117	0.717	118

Table 3. Comparison and check stars for TZ PER.

Source	T_{max} (Reported)	Period (d)	Cycles	T_{max} (Calc)	O-C$_{GCVS}$ (d)	O-C$_{new}$ (d)
GCVS	2419902.4324	0.391674615			+0.000000	+0.0000000
Agerer (2002)	2451952.3952		81828	2451952.3828	+0.012404	+0.0004282
	2452279.4415		82663	2452279.4311	+0.010400	+0.0025626
Agerer (2003)	2452188.5713		82431	2452188.5626	+0.008711	+0.0042156
	2452321.3497		82770	2452321.3403	+0.009416	+0.0035632
Le Borgne (2004)	2453034.5980		84591	2453034.5798	+0.018243	–0.0049773
Le Borgne (2005)	2453354.5890		85408	2453354.5779	+0.011082	+0.0023113
Hubscher (2005a)	2451898.7360		81691	2451898.7234	+0.012626	+0.0001844
	2452949.5942		84374	2452949.5864	+0.007834	+0.0053972
	2453069.4545		84680	2453069.4388	+0.015702	–0.0024226
	2453098.4380		84754	2453098.4227	+0.015280	–0.0019895
Hubscher (2005b)	2453378.4798		85469	2453378.4701	+0.009731	+0.0036724
	2453407.4691		85543	2453407.4540	+0.015109	–0.0016945
	2453705.5310		86304	2453705.5184	+0.012627	+0.0009068
Le Borgne (2006a)	2453343.6220		85380	2453343.6110	+0.010971	+0.0024177
Jurcsik (2006)	2453737.6470		86386	2453737.6357	+0.011309	+0.0022381
Le Borgne (2006b)	2453654.6123		86174	2453654.6007	+0.011627	+0.0018865
Hubscher (2006)	2453745.4823		86406	2453745.4691	+0.013116	+0.0004335
	2453751.3555		86421	2453751.3443	+0.011197	+0.0023551
	2453752.5340		86424	2453752.5193	+0.014673	–0.0011206
	2453760.3658		86444	2453760.3528	+0.012981	+0.0005749
	2454034.5370		87144	2454034.5251	+0.011950	+0.0017151
Le Borgne (2007a)	2454036.4950		87149	2454036.4834	+0.011577	+0.0020890
	2454039.6300		87157	2454039.6168	+0.013180	+0.0004872
	2454045.5050		87172	2454045.4919	+0.013061	+0.0006088
	2454058.4260		87205	2454058.4172	+0.008799	+0.0048762
	2454061.5610		87213	2454061.5506	+0.010402	+0.0032744
	2454081.5370		87264	2454081.5260	+0.010997	+0.0026878
	2454091.3290		87289	2454091.3179	+0.011131	+0.0025571
	2454100.3380		87312	2454100.3264	+0.011615	+0.0020768
	2454108.5620		87333	2454108.5516	+0.010448	+0.0032470
Le Borgne (2007b)	2454192.3850		87547	2454192.3699	+0.015081	–0.0013518
	2454194.3380		87552	2454194.3283	+0.009708	+0.0040221
	2454136.3723		87404	2454136.3604	+0.011851	+0.0018558
Hubscher (2007)	2454174.3650		87501	2454174.3529	+0.012113	+0.0016087
	2454203.3488		87575	2454203.3368	+0.011991	+0.0017418
	2454488.8794		88304	2454488.8676	+0.011797	+0.0020505
Warner	2454489.6648		88306	2454489.6510	+0.013848	+0.0000000
	2454489.6648					
SPAN	2454489.6648		88306	0.39167477	-0.00000016	

Table 4. Times of minimum for TZ PER. See the caption for Table 2 for a description of the column values.

5.3 SV CNC

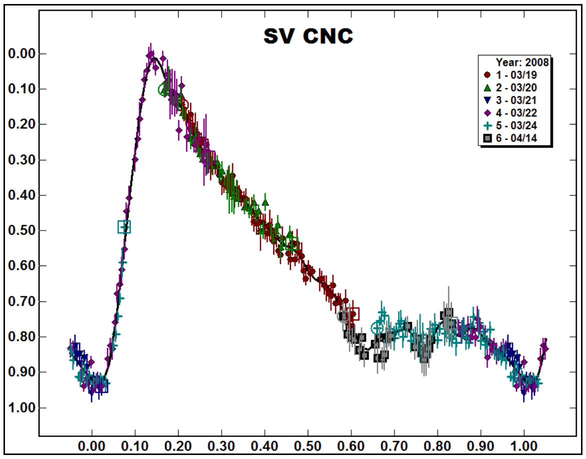


Figure 6. Plot of SV CNC, R-filter.

SV CNC was worked on 2008 March 19-22 and 24 using only the R filter. The amplitude of the curve ranged from R = 13.78 to 14.68. The “hump” near minimum light is a little more pronounced in this star that the other two in this paper (Figure 6). V observations were made for a short interval on one night in 2008 April near minimum light, to determine the maximum V-R difference (0.361 ± 0.032)

There was no sequence from the AAVSO for this star, so I developed my own. Table 5 gives the magnitudes and color indices for the comparisons, check, and variable.

Other than the epoch and period in the GCVS, I could find no times of maximum in the IBVS or other journals. The GCVS gives the period as 0.52619880 d. However, the Fourier analysis in MPO Canopus found a period of 0.52654 ± 0.00006 d. This latter period is based on data that covers time of maximum only once.

If the GCVS period is adopted as being nearly correct, this results in 29879 cycles between GCVS epoch and the measured time of maximum, T = 2454547.7441 ± 0.0023, or O-C = –0.0948 d. Using the total time span and 29879 cycles, this results in a new period of 0.52619563 d, or a difference between the periods (GCVS–Warner) of ΔP = 0.00000317 d.

On the other hand, if the period found by Fourier analysis is assumed, this results in 29850 (-29) cycles and O-C = –0.0944 d, almost identical to the previous result.

	ID (UCAC 2)	RA	Dec	V	R	V-R	Chart ID
Variable	SV CNC	08 50 00.90	+09 59 47.0			0.361	
Comp	35392836	08 50 14.82	+10 02 05.0	13.359	13.087	0.272	A
Comp	35392826	08 50 00.22	+10 00 23.5	14.664	14.225	0.439	B
Comp	35392823	08 49 57.80	+10 01 14.1	14.399	14.049	0.350	D
Check	35209245	08 49 48.97	+09 57 54.7	13.893	13.515	0.378	C

Table 5. Comparison and check stars for SV CNC.

6. References

Agerer, F., Dahm, M., Hübscher, J. (1999) “Photoelectric Minima of Selected Eclipsing Binaries and Maxima of Pulsating Stars.” *IBVS* **4712**.

Agerer, F., Hübscher, J. (2000) “Photoelectric Minima of Selected Eclipsing Binaries and Maxima of Pulsating Stars.” *IBVS* **4912**.

Agerer, F., Hübscher, J. (2002) “Photoelectric Minima of Selected Eclipsing Binaries and Maxima of Pulsating Stars.” *IBVS* **5296**.

Agerer, F., Hübscher, J. (2003) “Photoelectric Minima of Selected Eclipsing Binaries and Maxima of Pulsating Stars.” *IBVS* **5485**.

Good, Gerry A. (2003) *Observing Variable Stars*. Springer-Verlag London Ltd., London. pp. 274.

Henden, Arne A., Kaitchuck, R.H. (1990) *Astronomical Photometry: A Text and Handbook for the Advanced Amateur and Professional Astronomer*. Willmann-Bell, Richmond, VA. pp. 395.

Hübscher, J. (2005a) “Photoelectric minima of selected eclipsing binaries and maximum of pulsating stars.” *IBVS* **5643**.

Hübscher, J., Paschke, A., Walter, F. (2005b) “Photoelectric minima of selected eclipsing binaries and maximum of pulsating stars.” *IBVS* **5657**.

Hübscher, J., Paschke, A.; Walter, F. (2006) “Photoelectric Minima of Selected Eclipsing Binaries and Maxima of Pulsating Stars.” *IBVS* **5731**.

Hübscher, J. (2007) “Photoelectric Minima of Selected Eclipsing Binaries and Maxima of Pulsating Stars.” *IBVS* **5802**.

Jurcsik, J.; Sódor, Á.; Váradi, M.; Vida, K.; Posztobányi, K.; Szing, A.; Hurta, Zs.; Dékány, I.; Washuettl, A.; Vityi, N. (2006) “BVR_cI_c photometry of three RRab stars”. *IBVS* **5709**.

Le Borgne, J.F., Klotz, A., Boër, M. (2004) “The GEOS RR Lyr Survey: Maxima of RR Lyr stars observed by the automated telescope TAROT.” *IBVS* **5568**.

Le Borgne, J.F., Klotz, A., Boër, M. (2005) “Second list of maxima of RR Lyr stars observed by the automated telescope TAROT.” *IBVS* **5622**.

Le Borgne, J.F., Klotz, A., Boër, M. (2006a) “Fourth list of maxima of RR Lyr stars observed by the automated telescope TAROT.” *IBVS* **5686**.

Le Borgne, J.F., Klotz, A., Boër, M. (2006b) “Fifth list of maxima of RR Lyr stars observed by the automated telescope TAROT.” *IBVS* **5717**.

Le Borgne, J.F., Klotz, A., Boër, M. (2007a) “Sixth list of maxima of RR Lyr stars observed by the automated telescope TAROT.” *IBVS* **5767**.

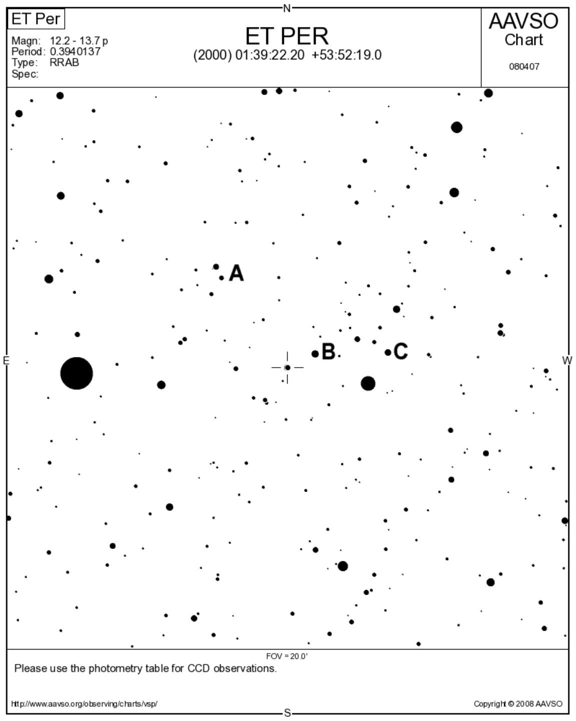
Le Borgne, J.F., Klotz, A., Boër, M. (2007b) “Seventh list of maxima of RR Lyr stars observed by the automated telescope TAROT.” *IBVS* **5767**.

Kholopov, P.N., et al., 1985, *General Catalogue of Variable Stars*, Moscow: Nauka Publishing House, 1988, 4th ed., edited by Kholopov, P.N.; Web edition (http://www.sai.msu.su/groups/cluster/gcvs/).

North, Gerald (2004). Observing Variable Stars, Novae, and Supernovae. Cambridge University Press. London. pp. 230.

Percy, John R. (2007) *Understanding Variable Stars*. Cambridge University Press, New York. pp 350.

Sódor, Á.; Jurcsik, J.; Nagy, I.; Váradi, M.; Dékány, I.; Vida, K.; Hurta, Zs.; Posztobányi, K.; Vityi, N.; Szing, A.; Dobos, V.; Kuti, A. (2007) “Multicolour CCD Photometry of Three RRab Stars”. *IBVS* **5793**.


ET Per
Magn: 12.2 - 13.7 p
Period: 0.3940137
Type: RRAB
Spec:
ET PER
(2000) 01:39:22.20 +53:52:19.0
AAVSO
Chart
080407
N
E
W
S
A
B
C
FOV = 20.0'
Please use the photometry table for CCD observations.
http://www.aavso.org/observing/charts/vsp/
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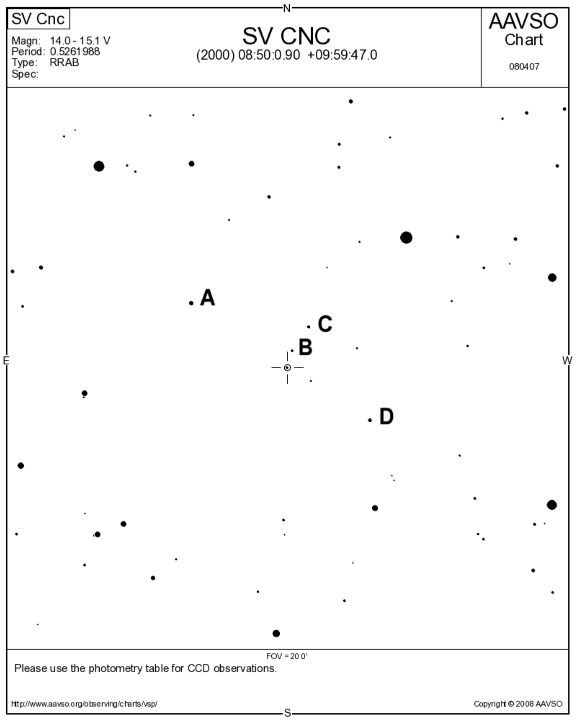
SV Cnc
Magn: 14.0 - 15.1 V
Period: 0.5261988
Type: RRAB
Spec:
SV CNC
(2000) 08:50:0.90 +09:59:47.0
AAVSO
Chart
080407
N
E
W
S
A
B
C
D
FOV = 20.0'
Please use the photometry table for CCD observations.
http://www.aavso.org/observing/charts/vsp/
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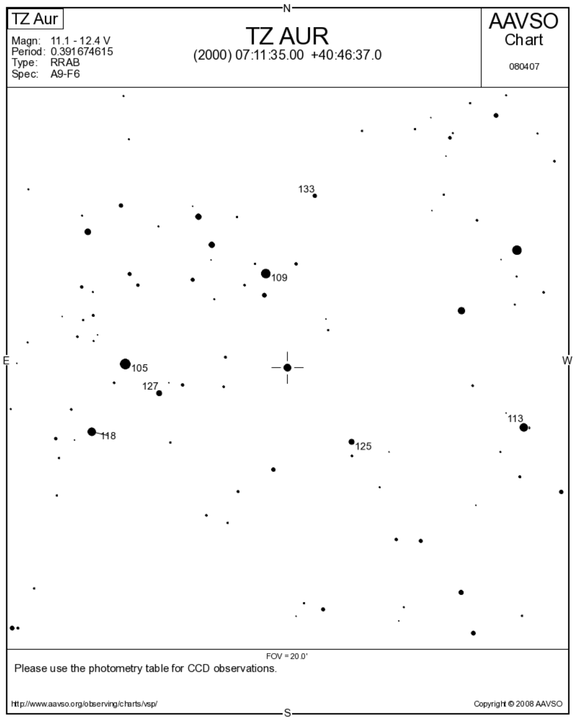
TZ Aur
Magn: 11.1 - 12.4 V
Period: 0.391674615
Type: RRAB
Spec: A9-F6
TZ AUR
(2000) 07:11:35.00 +40:46:37.0
AAVSO
Chart
080407
N
E
W
S
133
109
105
127
118
125
113
FOV = 20.0'
Please use the photometry table for CCD observations.
http://www.aavso.org/observing/charts/vsp/
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