Visual Measurements of a Selected Set of 20 Double Stars

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Abstract: The observations and measurements for a selected set of twenty binary stars are reported. These tasks comprised the activities in a continuation of a special mathematics course devoted to research techniques being taught at the Estrella Mountain Community College in Avondale, Arizona. The fall 2010 semester focused on telescope operations, observations and measurements of a selected set of ten binary stars and an analysis of their proper motion. The spring 2011 semester extended the observational sessions and measurements to a set of an additional twenty binary stars. In addition, the comparison of a selected subset of measurements taken with a webcam was compared to visual observations. All observation were taken with a Meade 12" Schmidt Cassegrain Telescope (SCT) using the Celestron MicroGuide™ for measurements.

Introduction and Instrumentation

This observation program is part of a special mathematics class conducted during the fall 2010 and spring 2011 semesters at the Estrella Mountain Community College located in Avondale, Arizona. This mathematics course is designed to give students an introduction to performing real-world research with the end goal of collecting measurement data which is of sufficient quality to be of value to the scientific community. Measurement data collected during the fall 2010 semester has been published in the April 2011 edition of Journal of Double Star Observations, Volume 7 Number 2. The approach and results for the spring 2011 semester observing sessions were presented at a conference talk at the 30th Annual Conference on Telescope Science in Big Bear Lake, California conducted by the Society for Astronomical Sciences. The selection of researching binary stars was chosen since the observation and measurements of double star systems are an area which can be achieved with the use of small telescopes.

The instrumentation used for observations and measurements consisted of a Meade 12" LX200GPS F/10 Schmidt-Cassegrain telescope. This system contained the GPS feature which made initial setup and calibration fast and easy. Visual double star measurements were obtained using the Celestron MicroGuide™ eyepiece which is a 12.5 mm F/L Orthoscopic with a reticule and variable LED.

All observations were taken on the campus of Estrella Mountain Community College campus located at 33^0 28' 49.46" N, 112^0 20' 36.47" W during evening hours which generally consisted of between 6:00 and 9:00 PM local time (01:00 to 04:00 UT). Observations and measurements covered the dates from late February 2011 through early April 2011.

Selection of Stars

As in fall 2010, the selection of stars for observation and measurement were taken from the Washington Double Star Catalog (WDS). The WDS is maintained by the United States Naval Observatory and is the world's principal database of astrometric double and multiple star information containing positions (J2000), discoverer designations, epochs, position angles, separations, magnitudes, spectral types, proper motions and when available, Durchmus-

terung numbers and notes for the components of 108,581 star systems. The current version of the WDS is updated nightly.

The initial approach in fall 2010 was to select a set of target stars from the neglected list on the WDS main web page. However, in the process of attempting actual measurement data it was determined that many of the stars on the original target list of neglected stars were beyond the observational capabilities of the observing site and the equipment. As results of these limitations, the original list was expanded to include a broader range of stars taken from the 18-24 hour section of the WDS catalog website. The criteria for observations were modified to the following:

- Primary and companion being magnitude 9 or brighter
- At least one magnitude difference between the primary and companion
- Separation distance being greater than 5 and less than about 300 arcsecs

This relaxed criteria list proved to be a nice combination of target stars in need of observation and available enough for the telescope equipment. This approach was duplicated for the spring 2011 semester with the list of target stars now occupying the sky from 5 to 9 hrs RA.

Visual Measurements of Selected Binary Stars

Duplicating the approach in fall 2010, the measurements of the separation distance and position angle of the selected target stars was accomplished using a standard visual observational approach. All measurements were acquired utilizing the Celestron MicroGuide™. In order to produce high quality measurements, care was taken in calibrating the measurement instrument and performing a series of test measurements for validation of results before proceeding to the measurements of the target stars.

MicroGuide Calibration

Care was taken during fall 2010 to calibrate the Celestron MicroGuide™ in order to obtain the highest precision measurements. The technique for calibration was the standard star drift method with the process being carried out over several nights using all observers in order to minimize any observer and instrumentation bias. The approach consisted of locating a target star of sufficient visual magnitude as close to the zenith as possible. An observer centered the star along the microguide's linear axis and the telescope drive was temporary switched off to allow the star to drift down the linear scale. After an observer's timing measurement was acquired, the telescope's drive was reactivated and the star repositioned to begin another timing run. A different observer took the next timing measurement. This round-robin approach was applied to achieve a series of independent measurements for each observer. These measurements were then averaged to produce the calibration for this observing system.

Calibration results for fall 2010 resulted in a mean measurement of 38.26 seconds per drift. A histogram distribution of drift measurement points is shown in Figure 1.

The process was repeated for spring 2011 which resulted in the histogram shown in Figure 2 with a mean drift time of 32.21 seconds.

A review of Figures 1 and 2 indicates a non Gaussian distribution of observation measurements were obtained in fall 2010 and a more symmetric Gaussian

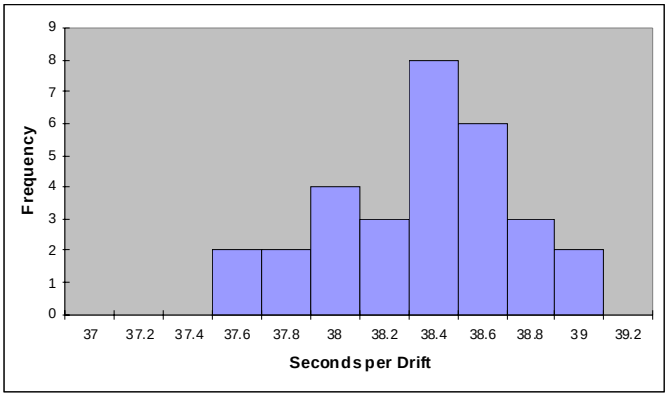

Figure 1: Histogram of Calibration Measurements – Fall 2010

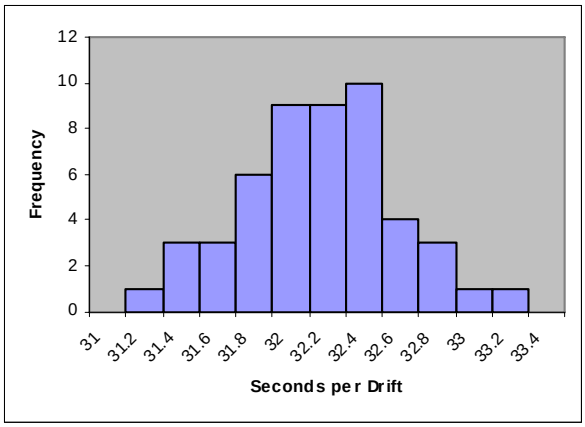

Figure 2: Histogram of Calibration Measurements – Spring 2011

Table 1: Summary Results for MicroGuide™ Calibration

Period	Average	1 STD
Fall 2010	38.26	0.38
Spring 2011	32.21	0.43

type distribution obtained in spring 2011. The mean and the one standard deviation for both calibration runs are shown in Table 1.

Using the standard calibration formula for the MicroGuide resulted in a value of 7.26 arcsecs per MicroGuide grid interval for the fall 2010 measurements and 7.39 arcsecs per grid interval for spring 2011. The difference was attributed to equipment calibrations during the time intervals.

Measurements Process

A round robin technique used for taking new measurement data was utilized repeating the process used in fall 2010. Separation was measured by orienting the selected systems along the Microguide's linear scale, and noting their separation as indicated by the scale's tick marks. Position angle was then measured by aligning the binary systems along the linear scale, with the primary star directly on mark 30, and the secondary along the scale between marks 30 and 60. After the stars were aligned, the telescope's tracking system was temporarily disabled, allowing the binary system to drift out of the eyepiece's field of view. The binary system crossed over the circular scale which runs along the edge of the telescope's FOV, as this happened the position of the secondary star along this circular scale was noted. 90 degrees were then added or subtracted from this measurement, depending upon orientation, to achieve our final Position Angle measurements. These processes were repeated several times per system for separation accuracy. Summary of measurement data are shown in Table 2.

Table 2: Summary Data for Measures 2011

WDS ID	Discover.	Magnitudes		Last			Current		
		Primary	Sec	Epoch	PA	SEP	Epoch	PA	SEP
08525+2816	HJ 460AC	6.47	6.04	2005	21	273.5	2011.2	20	276.8
06212+2108	S 513AD	7.31	7.61	2009	24	264.7	2011.2	24	274.7
07183-3644	JC 10AB	4.66	5.07	1999	98	240.1	2011.2	102	241.6
08142+1741	STU 22AB-D	6.51	8.94	2002	325	230.1	2011.2	320	230.5
08476+0001	STU 23AC	7.84	7.82	2004	352	217.3	2011.204	351	219.9
06047-4505	HJ 3834AC	6.02	6.39	1999	321	196.2	2011.204	323	202.9
08102+2551	ARN 2AC	6.58	8	2007	22	188.7	2011.204	21	195.5
07040-4337	DUN 38AC	5.61	8.83	1999	335	184.9	2011.204	337	185.7
07097+6045	HJL1046AB	6.76	7.95	1999	165	182.2	2011.238	164	184.8
07013+3225	ARN 66AF	6.59	8.26	2004	301	169.9	2011.238	301	172.0
08401+2000	ENG 37AB	6.47	6.58	2010	153	148.2	2011.238	151	155.3
06376+1211	S 529AC	6.91	8.09	2002	168	142.2	2011.238	168	143.0
07260+1406	STF1088AE	7.38	8.1	1984	224	137.4	2011.244	223	119.6
08085-1952	S 563AB	7.03	7.62	2002	57	134.3	2011.244	60	140.2
06255-3504	HJ 3858AB	6.4	7.61	2007	47	131.8	2011.258	48	134.4
08404-4223	DUN 72AB	6.91	7.8	1999	360	129.8	2011.258	1	130.2
07478-1601	KNT 4AB	6.54	6.6	2002	132	129.4	2011.258	131	130.8
07183-3644	JC 10BC	5.07	8.67	1999	216	117.2	2011.263	215	118.9
06541+0641	STTA 79	7.2	7.52	2004	89	115.5	2011.263	96	117.9
07254+5633	STTA 84AB	7.72	7.75	2004	324	113.6	2011.263	325	115.0

Figure 3: Imagery for S529 AC

Figure 4: Imagery for STF1088A

Video Imagery of Selected Stars

Toward the end of the visual star observing program, a Phillips 900NC video web camera was used to investigate capturing imagery of a selected set of the binary stars. The primary objective of the experiment was to determine the capabilities of low cost web cameras for use in obtaining high precision measurements of double stars. A second objective was to determine whether a web camera could obtain imagery of doubles with fainter magnitudes than would be observable with visual means. During an observing session conducted over successive nights, 8 binary star pairs were captured. Several examples are described in detail.

Binary S529 AC primary is magnitude 6.91 with a secondary at magnitude 8.09. See Figure 3. The last measurement in the WDS database indicated a separation of 142.2 arc-seconds and position angle of 160 degrees. The epoch was 2002.

Binary STF1088A primary is magnitude 7.38 with a secondary at magnitude 8.1. See Figure 4. The last measurement in the WDS database indicated a separation of 137.4 arc-seconds and position angle of 224 degrees with an epoch of 1984.

Binary STTA84AB (Figure 5) has a primary at magnitude 7.72 with a secondary at magnitude 7.75. The WDS database indicates a separation of 113.6 arc -seconds and position angle of 324 degrees with an epoch of 2004.

Overall, 8 stars were successfully imaged with magnitudes ranging from 6.4 up to 8.26. Imaging of fainter stars was not possible with direct video capture. Preliminary analysis utilizing stacking techniques was attempted but none were successful. Additional work needs to be performed in this area.

Figure 5: Imagery for STTA84AB

Analysis of Separation using REDUC

REDUC is a software package dedicated to double stars measurements. The latest version can be downloaded free on simple demand. It is perfectly adapted to performing measurements on imagery captured with simple CCD and video cameras as demonstrated here. The main window shown in Figure 6

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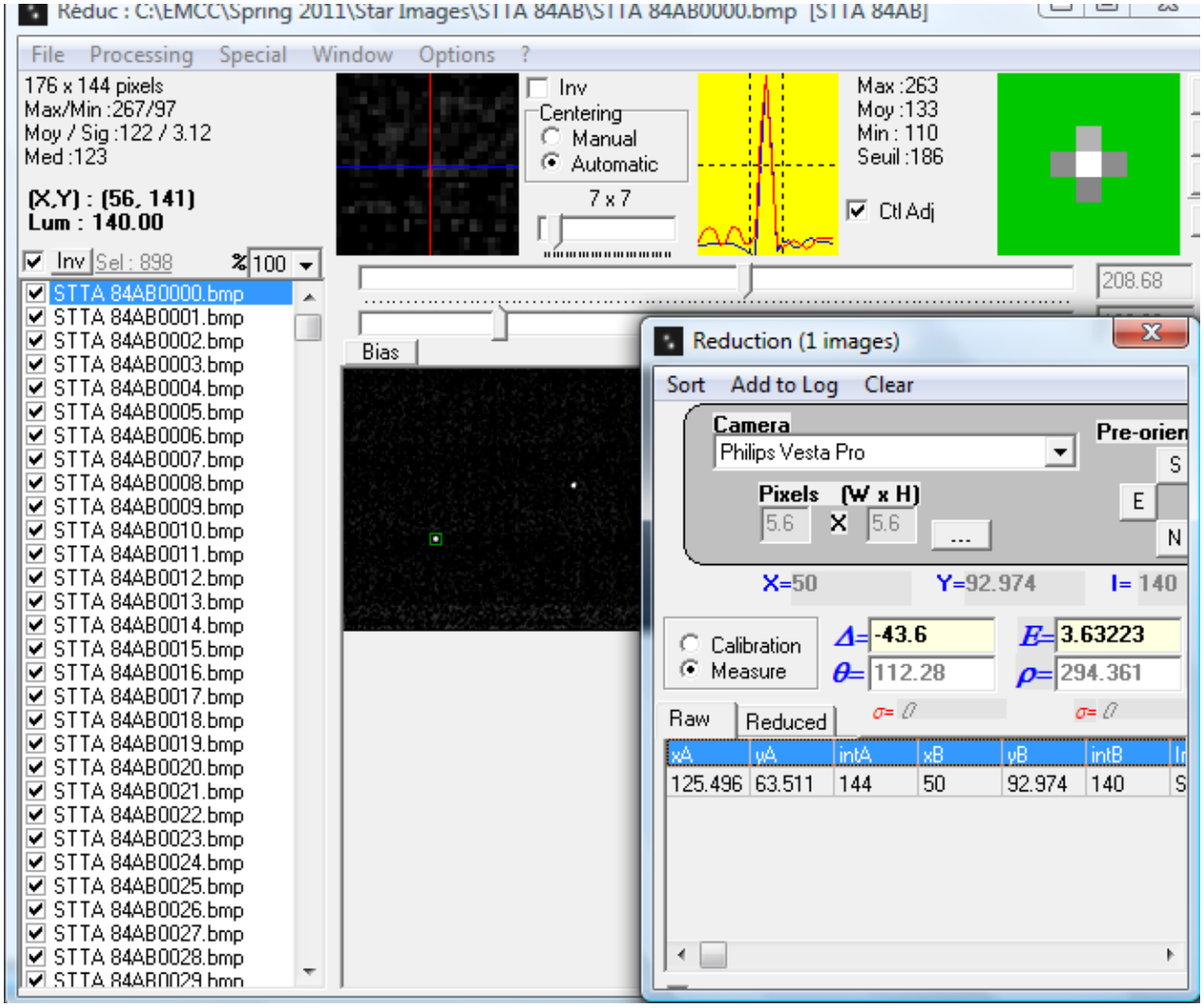

Figure 6: REDUC Main Window

Table 3: Comparison of Visual and Imaged Separation in Arc-seconds

	Separation (as)			
Star	**WDS**	**Observed**	**Imaged**	**% Accuracy to WDS**
STTA 84AB	115	115.5	117.3	98
STF1088AE	137.4	119.6	135.2	98

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provides the ability to load AVI files, select specific targets and then performs accurate measurements once it is calibrated.

To provide test data on the utilization of REDUC, star pair S 529AC was loaded and use as a calibration set. This was applied to star pairs STTA 84AB and STF1088AE with results shown in Table 3.

This limited test shows the promise of using inexpensive video imaging equipment for stars brighter than about magnitude 9. Additional image processing techniques could be applied to image fainter stars but to what magnitude limit would be obtainable is currently unknown.

Conclusion

These observations provide additional information for researchers to investigate the nature of binary systems.

Acknowledgments

We would to thank Becky Baranowski, Department Chair for Mathematics, Physics, and Astronomy for offering this course for the year 2010/2011 and to the Estrella Mountain Community College for use of equipment and facilities.

References

1. Ronald Charles Tanguay, Observing Double Stars for Fun and Science
2. Argyle, Bob, Observing and Measuring Visual Double Stars, Springer-Verlag London Limited 2004
3. Sky and Telescope Magazine, March 2011
4. The Celestron Micro Guide Eyepiece Manual (#94171)