Student Measurements of Double Star STF 747AB

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Abstract: Data gathered from a 22-Inch Newtonian Alt/Az telescope and a Celestron Micro Guide eyepiece were used to measure the double star STF 747AB. Students from Apple Valley High School determined the separation to be 39.97 arc sec and the position angle to be 227.91 degrees. The students also used data from the digitized sky survey and determined a separation of 39.99 arc sec and a position angle of 225 degrees. The research was semi-independent from the Vanguard Double Star Workshop 2016 in Apple Valley, California.

Introduction

Vanguard Preparatory School hosted a three day double star workshop from March 11 through March 13. A number of high school students participated in measuring scale constant, plate scale, separation, and position angle of the double star system STF 747AB. These students had participated in previous double star workshops hosted by Vanguard Preparatory and worked semi-independently using images that were gathered by Chris and Reed Estrada on March 10 with a 22-inch Newtonian Alt/Az telescope and a Celestron Micro Guide eyepiece fitted with a Bell and Howell High Definition Video Camera as well as images gathered from the Digitized Sky Survey.

The double star system STF 747AB is located in the Orion constellation. STF 747AB has a blue primary star with a magnitude of 4.7 and a blue secondary star with a magnitude of 5.5. The right ascension and declination are listed in the Washington Double Star Catalog as 053502.68-060007.2. The double star was first measured in 1825 and a total of 49 measurements have been documented in the WDS. The latest measurement of STF 747AB was in 2014 with a separation of 35.9 arc sec and a position angle of 224 degrees. This star was selected for its magnitude, position angle, and separation.

Equipment and Procedures

The team, pictured in Figure 1, in this study used a 22-inch Newtonian Alt/Az telescope (Figure 2) with a Celestron Micro Guide eyepiece fitted with a Bell and Howell high definition video camera. The use of the video camera offsets the need for a drive motor and negates the field rotation common with telescopes that use Alt/Az.

Figure 1: The authors from left to right in the back row: Scott Sharpe, Travis Gillette, Benjamin Funk, and Ruth Schlosser. The authors from left to right in the front row: Grace Bateman, Breauna Rhoades, and Leone Thompson. Picture was taken by Mark Rhoades.

The star Bellatrix was used to calibrate the telescope to the Celestron Micro Guide eyepiece for separation measurements. To calibrate the telescope, the

Figure 2: This is a picture of the telescope used to collect digital data of the double star. Picture taken by Chris Estrada.

eyepiece was rotated so that the star would drift parallel to the linear scale. The star was placed on the easternmost part of the linear scale and allowed to drift along the linear scale. A video was taken of the drift. The process was repeated seven times. The videos were then viewed 15 times to determine the average scale constant using the equation

$$Z = \frac{15.0411\, t \cos(dec)}{D}$$

where Z is the scale constant in arc sec per division; 15.0411 is the rotation of the earth in arc sec per second; t is the average drift time in seconds; dec is the declination of the calibration star (20.982); and D is the number of tick marks on the linear scale. The result for the 22-inch Newtonian Alt/Az with a Celestron Micro Guide eyepiece was 7.95 arc sec per tick mark.

The authors also used data from the digitized sky survey in order to measure separation and position angle of STF 747AB. The students aligned an image of the double star system on a coordinate plane and used the formula:

$$\frac{206264.806 \text{ arc sec(pixel size)}}{\text{(focal length)}}$$

in order to determine the plate scale. The pixel size was 15 microns and the focal length was 3073.4 millimeters. The plate scale was determined to be 1.01 arc sec per pixel. In order to determine the separation, the authors then used the formula

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

where d is the distance between the primary and secondary star, (x_1,y_1) are the coordinates of the primary star, and (x_2,y_2) are the coordinates of the secondary star. The distance between the primary and secondary star was determined to be 39.59 pixels. This measurement was multiplied by the plate scale constant of 1.01 arc sec/pixel to be converted into arc seconds. The measured separation was 39.99 arc seconds. The authors then used the formula

$$\theta = \arctan \frac{\Delta y}{\Delta x}$$

where θ is the position angle, Δy is the difference between the y coordinates of the primary and secondary stars, and Δx is the difference between the x coordinates of the primary and secondary stars. From this formula the authors found a position angle of 45 degrees, and when adjusted by 180 degrees, the measured position angle is 225 degrees.

Observation and Analysis

Our video data was recorded on B2016.191904 (March 10, 2016) in Antelope Valley, California and our measurement results are presented in Table 1. The Digitized Sky Survey Data was imaged on B1990.983571 at Palomar Observatory and reduced on B2016.194642. Results of the reduction are given in Table 2.

Conclusion

The students' results measured from video data were slightly different from values published in the Washington Double Star Catalog in 2014 with a separation and position angle difference of 4.17 arc sec and 3.91 degrees. The authors have concluded that the large separation difference may have been due to random and systematic errors such as the Micro Guide eyepiece ± 0.5 arc sec, the stopwatch ± 0.5 sec, the author' difference in vision, and reaction time. The authors also found the difference from the digitized sky survey to be 4.1 arc sec and 1.0 degrees. The authors have concluded that the large separation difference may have been due to random and systematic errors. The pixel size ± 0.5 microns and the focal length ± 2.0 mm, and star's centroid values ± 0.5 were determined from DS9.

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Table 1: Measurements of Double Star System STF 747AB From our Video Data. Taken on B2016.191904

Parameters	# Obs	Mean	SD	Standard Error of Mean	WDS Value	Difference	% Difference
Scale Constant arc sec / division	15	7.94	0.88	0.226	NA	NA	NA
Separation (arc sec)	12	39.97	0.68	0.197	35.9	4.17	11%
Position Angle (degrees)	12	227.91	1.24	0.357	224	3.91	1.7%

Table 2: Double Star System STF 747AB with Digitized Sky Survey Data. Data gathered on B1990.983571.

	Student Measured Value	WDS Published Value	Difference	Percent Difference
Plate Scale (arc sec/pixel)	1.01 arc sec/pixels	N/A	N/A	N/A
Separation (arc sec)	39.99 arc sec	35.9 arc sec	4.09 arc sec	10.78%
Position Angle (degrees)	225 degrees	224 degrees	1 degree	0.45%

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