Observations of Omicron 1 Cygni (STFA 50AD)

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Abstract: In over 215 years, the star STFA 50AD located in the Cygnus constellation has only been analyzed about 35 times. A group of eight individuals from five affiliations participated in the third annual Apple Valley Double Star Workshop to measure the separations and position angles of a double star. During this workshop, data from several astronomical identifiers was used to compare the data collected. The main apparatus used was an 8-inch telescope. An astrometric eyepiece and a stopwatch were used. The scale constant 9.9 arc seconds per division mark, separations 340.9 arc seconds, and position angles 324.1 degrees were determined by the telescope-eyepiece combination. The plate scale 1.01 arc seconds per pixel, separation 337.1 arc seconds, and position angle 321.3 degrees were determined by using the Digitized Sky Survey and Astrometrica. The results obtained were compared to previous observations listed in the Washington Double Star Catalog. After rigorous calculations and teamwork, it was concluded that the 2008 results were determined to be an outlier.

Introduction

A three-day double star workshop was held by the High Desert Astronomical Society (HiDAS) and the Central Coast Astronomical Society (CCAS) to measure and report on the double star system Omicron 1 Cygni (STFA 50AD). The observations were made at the Thunderbird campus of the Lewis Center for Educational Research in Apple Valley, California, by a team of students from Fullerton College, Victory Valley Young Marines, University of California, Riverside, Victor Valley College, and California State University, San Bernardino. A group photograph of the observing team is shown in Figure 1.

The star system STFA 50AD is identified in the Washington Double Star Catalog (WDS) as 20136+4644, located at right ascension 20 hours 13 minutes 38 seconds and declination +46 degrees 44 minutes. The magnitudes of the primary and secondary

Figure 1. A group photo of the team. In the background from left to right: Paul McGuire, Nicole Richardson, Jeff Bidler, and Arturo Rodriguez. In the foreground from left to right: Rosa McGuire, Mark Brewer, Leslie Montes, and Joshua Hagee.

Figure 2: An image of the double star system STFA 50AD from the Digitized Sky Survey (DSS).The image was captured September 11, 1990 at 4:32:00 U.T.

stars are listed as 3.93 and 4.83. Figure 2 is a DSS image of this system. We compared our observations to early 19th century and 20th century observations, as well as the most recent observations listed in the WDS.

The WDS and the Set of Identifications, Measurements, and Bibliography for Astronomical Data (SIMBAD) were used to find different identifiers, including HD 192577, HIP 99675, and SAO 49337.

Equipment and Procedures

A Meade 8-inch Schmidt Cassegrain telescope on a Celestron German equatorial mount equipped with a Celestron 12.5 mm Micro Guide astrometric eyepiece and a stopwatch that reads to the nearest thousandth of a second were used.

A drift method was used to calibrate and determine the scale constant of the telescope-eyepiece combination. The drift method was conducted by disabling the drive motor and timing the primary star's drift along the linear scale. A total of ten drift measurements were recorded. The scale constant was determined by the following equation:

$$Z = \frac{15.0411(T_{avg})\cos(dec)}{D}$$

where, Z equals the scale constant in arc seconds per division marks, 15.0411 equals Earth's rotational rate in arc seconds per second, $T_{avg.}$ equals the average drift time in seconds, cos (*dec*) equals the cosine of the primary star's declination, and D equals the total displacement of the linear scale.

The separation was determined by aligning both stars along the linear. The division marks between the objects were recorded. Ten measurements were recorded and an average was determined. To determine the separation in arc seconds, the average separation in division marks was multiplied by the scale constant. The average, standard deviation, and standard mean of error were calculated for 6 trials.

The position angle was determined by aligning both stars along the linear, with the primary star on the 30th division, which marks the precise center of the eyepiece. The clock-drive was then disengaged, allowing both stars to drift to the inner protractor ring of the eyepiece. When the primary star reached the inner protractor ring, the clock-drive was reengaged and the primary star's position was estimated to the nearest degree. The average, standard deviation, and standard mean of error were calculated for 10 trials.

The Palomar Digitized Sky Survey and Astrometrica were used. The plate scale, separation, and position angle of the double stars were determined. The plate scale was determined by the following equation:

$$Z = \frac{206264.806(pixel\_size)}{focal\_length}$$

where Z equals the plate scale in arc seconds per pixel, 206264.806 equals the factor of arc second in a radian, the pixel size is the size of one pixel in microns, and the focal length equals the distance that a photon travels through the telescope to the sensor.

The separation was determined using the following equation and multiplying the plate scale:

$$C = \sqrt{\Delta x^2 + \Delta y^2}$$

where C equals the total displacement in pixels, Δx equals the difference in the x axis, and Δy equals the difference in the y axis.

The position angle, θ, was determined by the following equation:

$$\theta = \arctan\left(\frac{\Delta y}{\Delta x}\right)$$

Observations and Analysis

Observations were made during the evening of June 17, 2015 (B2015.54082) in the west side parking lot of the Lewis Center for Educational Research in Apple Valley, California (N 34° 31' 58", W 117° 12' 48"). Observations took place during a phase of the Moon: Waxing Crescent with 3% of the Moon's visible disk illuminated according to the U.S. Naval Observatory Astro-

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Table 1. Student Measurements

	Units	# Obs.	Std. Dev.	Mean	Std. Mean Err.
Drift Time	seconds	10	1.0	57.5	0.3
Separation	arc seconds	6	0.5	340.9	0.2
Position Angle	degrees	10	1.1	324.1	0.34

nomical Applications Department, with fair sky conditions and a temperature of 78.8 degrees. Table 1 lists the averages (mean), standard deviations, and standard errors of the mean for the drift time, separation, and position angle measurements.

Table 2 lists the number of observations, the separation, and position angle measurements. Table 3 shows a comparison of the team's data gathered from the eyepiece versus data listed in the WDS. The measurement on the position angle differs only by 0.3% compared to the data obtained during the observations compared to the 1800 and 2008 epochs. The position angle measurements compared to 2003 epoch differ by 0.4%. However, there is a difference in the measurements of separation of 0.9% with the data from 1800 and a 2.1% difference with the data obtained in 2008. The separation percentage differences compared to 2003 epoch differ by 1.2%. The large differences in the measurement of separation on 1800, 2003, and 2008 can be explained by the use of an astrometric eyepiece, a small telescope, and the total displacement of the double star on the eyepieces' linear scale. The large displacement of the stars on the scale made the observer strain to be accurate to half to a full division mark.

Table 4 shows a comparison of the team's data gathered from the image of the Digitized Sky Survey versus the data listed in the WDS. The measurements of the position angle differ by 1.0% compared to the 1800 epoch, 0.4% to the 2003 epoch, and 1.0% to the 2008 epoch. The measurements of the separation differ by 0.3% compared to the 1800 epoch, 0.1% to the 2003 epoch, and 1.0% to the 2008 epoch. The percentage differences determined by the use of the Digitized Sky Survey's image compare accurately to the three epochs listed in the WDS versus the differences of the astrometric eyepieces measurements.

Table 2. Student Measurements

	Units	# Obs.	Mean
Separation	arc seconds	1	337.1
Position Angle	degrees	1	321.3

Figures 3 and 4 show the comparison of the team's separation and position angle measurements versus the 35 measurements listed in the WDS. The plots show the significant differences for the eyepiece measurements compared to the DSS image. The plots also show the DSS separation measurement compares favorably to the mean values, while the DSS position angle and eye-

Table 3. Student Eyepiece Observations Compared to WDS Data

Historical Observations			Comparison to Present Study			
Epoch	**Position angle**	**Separation**	**Delta Position angle**	**Delta Separation**	**Percentage difference Position angle**	**Percentage difference Separation**
1800	324.5	338.0	0.9	2.9	0.3	0.9
2003	322.7	336.7	1.4	4.2	0.4	1.2
2008	324.6	333.8	0.9	7.1	0.3	2.1

Table 4. Student Digitized Sky Survey Observations Compared to WDS Data

Epoch	Position angle	Separation	Delta Position angle	Delta Separation	Percentage difference Position angle	Percentage difference Separation
1800	324.5	338.0	-3.2	-0.9	1.0	0.3
2003	322.7	336.7	-1.4	0.4	0.4	0.1
2008	324.6	333.8	-3.3	3.3	1.0	1.0

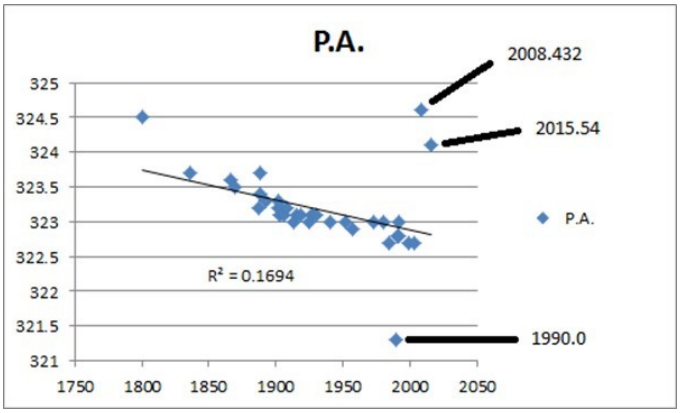

Figure 3. A graph of position angle measurements (35) listed in the WDS compared to the team's measurements 1990.0 and 2015.54

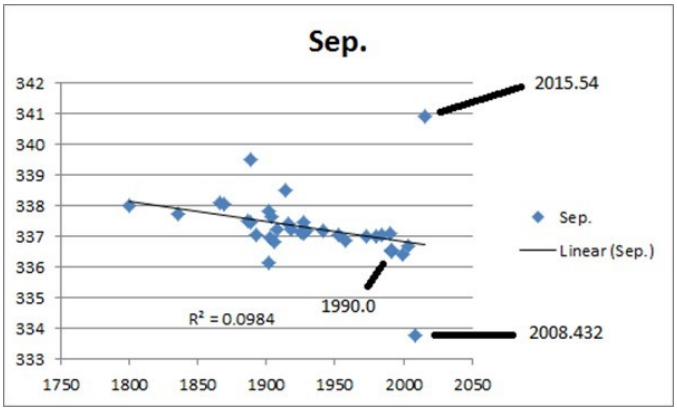

Figure 4. A graph of separation measurements (35) listed in the WDS compared to the team's measurements 1990.0 and 2015.54

piece separation and position angle measurements do not compare favorably.

Conclusion

At the end of the three day workshop, the team successfully measured the separations and position angles of the double star STFA 50AD with an astrometric eyepiece and an image from the Digitized Sky Survey. The team determined from the tables and plots that accurate measurements would only be acceptable to the Washington Double Star Catalog if digital images were gathered the nights of the event. The team did determine that the 2008 epoch listed in the WDS was an outlier compared to the mean values listed in the WDS.

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