Student Observations of Double Star Delta Orionis (STFA 14 AC)

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Abstract: A group of eight eighth graders and eight high schoolers studied the double star STFA 14 AC. They used the procedure from Argyle's book to get the separation and position angle for the double star. The students used a Celestron C8 Schmidt-Cassegrain telescope with a Baader Planetarium microguide eyepiece with similar markings to a Celestron Eyepiece. The students determined the separation to be 56 arcseconds and the position angle to be 4.19°. They compared their results to the Washington Double Star Catalog and found that they had a 2.88 arcseconds difference in separation and a 2.19° in position angle.

Introduction

A group of eight high school students and eight eighth graders observed and measured the double star STFA 14 AC, commonly referred to as Mintaka, at Vanguard Preparatory for the fourth Vanguard Preparatory Double Star Workshop (VDSW4). The Washington Double Star Catalog identifies this star as 05320-0018. The observations were made at 34.50°N latitude, 117.19°W longitude, Apple Valley, CA. Separation and position angle of the double star Mintaka were recorded on March 3, 2017, around 9:30 PM. The team members are shown in Figure 1.

Mintaka, also known as Delta Orionis, is a multiple star system located on the Western side of Orion's belt, or the rightmost part of it. Wikipedia states that it has a mythological origin coming from the name *mantaqa,* meaning "the belt" in Arabic. In the Washington Double Star Catalogue, the right ascension is 05h 32m 00.4009s and its declination is 17° 56m 74.24s. The magnitude of the primary star is 2.24 and the secondary's is 6.84, according to Underhill et al. (1979).

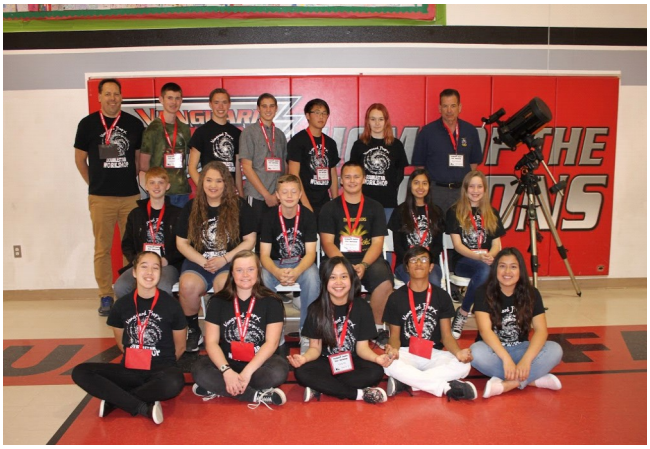

Figure 1: Team members for the present study. Back row left to right: Sean Gillette, Gabriel Reder, Travis Gillette, Scott Sharpe, Brendon Cha, Jenna Shattles, and Reed Estrada. Middle row left to right: Austin Thielen, Jalynn Givens, Malachi Ewing, Sam Bowden, Emilie Peña and Brenda Nelms. Front Row left to right: Maricarmen Richard, Breauna Rhoades, Vicky Do, Alex Junior Kiamco, and Sophia Aguilera.

Equipment and Procedures

A Celestron C8 Schmidt-Cassegrain Telescope with a 12.5mm Baader Planetarium Guide Eyepiece was used for the measurements (Figure 2). The telescope had a aperture of 203.2mm and a focal length of 2032mm The telescope was mounted on a Celestron Advanced VX. The Baader Planetarium eyepiece had a linear scale of 60. Our recorders used a stopwatch,

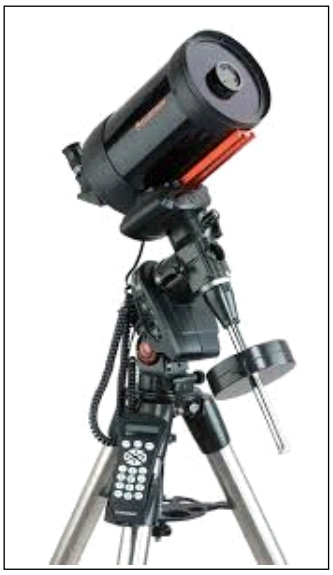

Figure 2: A photo of the telescope the student group used.

which reads to the nearest hundredth, to record the drift times. The observers used a flashlight to see the recorded drift times on the stopwatch. The measurements were recorded on a laptop in a Microsoft Excel spreadsheet with all the formulas already entered into the format.

The procedure used was as outlined in RW Argyle's book *Observing and Measuring Visual Double Stars*. The students found the drift time by calculating the seconds it took for the calibration star (Gamma Cassiopeia) to drift across the linear scale of the eyepiece ten times, found the average, and inserted that average into the mathematical equation:

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

Z represents the scale constant in arcseconds per division, *T* is the average time in seconds of drift. While *cos(dec)* represents the cosine of declination of the target star, or the angular distance north and south from the celestial equator measured along a circle going around the poles. In the group's case, cos*(dec)* is 0.4891, which is then multiplied by 15.0411 (rotational rate of the Earth in arcseconds per second) divided by *D* (linear scale's displacement), which is the number of tick marks on the linear scale of the eyepiece; in the student group's case, the displacement is 60.

The students determined the separation by observing the star system's placement by placing the primary and secondary star anywhere on the linear scale of the eyepiece, and then counting the number of tick marks on the linear scale between the primary and the secondary star. The stars would be moved in a different location along the line to eliminate any bias. After calculating the average separation, this average was multiplied by the scale constant (*Z*), which provided the separation written in arcseconds.

The position angle was found by placing the primary star on the linear scale, at the 30 mark (center of the linear scale) and rotating the eyepiece so that the secondary star falls on the linear scale. The observer would watch as the primary star drifted somewhere along the outer protractor ring once the drive motor was turned off. The observer would state the star's location in degrees. To remove bias, the eyepiece was rotated 180° every observation. The average was taken, which resulted in the position angle.

Observation and Analysis

The star, Mintaka, is a triple star system, and the group measured the Aa-C component. See Figure 3. The Aa component has a magnitude of 2.24, while the C component has a magnitude of 6.84, indicating that the system is quite bright. The star was first measured in 1777. The Washington Double Star (WDS) Catalog has recorded 22 prior observations since 1822, with a position angle of 0° and a separation of 52.5 arcseconds.

The star is located with a right ascension of 05h 32m 00.4009s and a declination of 00° 17mm 56.74.24s. The Washington Double Star Catalogue reported similar separation and position angle in 1996 as compared to the measurements reported at VDSW4. This is because the star moves very slowly over the years. The student group observed Mintaka from 9:23pm to 10:07pm on March 3, 2017. All observations, shown in Table 1, were taken at Vanguard Preparatory School, Apple Valley, CA. At the time of

Figure 3: A photo of Mintaka retrieved from the Digitized Sky Survey Epoch J2000.

Table 1: Observation of STFA 14 AC (WDS 05320-0018) 2017.169 (Besselian Year)

Parameters	# Obs	Mean	SD	Standard Error of Mean	WDS Value	Difference	% Difference
Scale Constant a.s. / division	9	9.98	1.53	0.51	NA	NA	NA
Separation (a.s.)	8	56.18	0.74	0.26	53.3	2.88	0.05
Position Angle (degrees)	8	4.19°	5.63	1.99	2	2.19	0.71

viewing, there was minimal light pollution and few or no clouds.

Conclusion

The students in Vanguard Double Star Workshop 4 were successful in measuring the separation and position angles of the double star, Mintaka, which has a separation of 53.3 arcseconds, and is at a position angle of 2°. The team's calculated average separation was 56.18 arcseconds and the calculated position angle in degrees was 4.19. The weather conditions during this process were good. They found their ending results to be consistent, along with one bad data set of 164.35 seconds for the drift time. The calculated scale constant of 9.98 arcseconds per division mark had a standard deviation of 1.53. These measurements may possibly be used in the future estimates of the Mintaka orbit.

Acknowledgements

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References

Argyle, 2012, *Observing and Measuring Visual Double Star,* 2nd edition, Argyle, RW., ed., Springer Publications, New York.

Mason, Brian, 2012, *Washington Double Star Catalog.* Astrometry Department, U.S. Naval Observatory, ad.usno.navy.mil/wds/wds.html.

"Mintaka", *Wikipedia*, Wikimedia Foundation, 30 Mar. 2017. Web. 03 Apr. 2017. https://en.wikipedia.org/wiki/Mintaka.