Double Star Measurements of Beta Scorpii

Sean Gillette[1,2], Benjamin Funk[3], Ruth Schlosser[3], Alana Brown[4], Mallikai Cruz[4], Jeff McCarthy[5], Breauna Rhoades[3], Bill Spreng[6]

1. Vanguard Preparatory School
2. High Desert Research Initiative
3. Apple Valley High School
4. Victor Valley College
5. High Desert Astronomical Society
6. Victor Valley Young Marines

Abstract: Eight observers met at the Lewis Center for Educational Research in Apple Valley, California. These observers studied the distance and position angle between β^1 and β^2 of the beta Scorpii star system. They used the drift method to calibrate the telescope-eyepiece, which was a Celestron C8 Schmidt-Cassegrain telescope equipped with an astrometric eyepiece. The star system γ Cassiopeiae was used to determine the scale constant of 4.6 arcseconds per division mark, using the average of twelve observations made of the star system using the drift method. A separation of 15.4 arcseconds and a position angle of 14.3 was determined using a Bader Planetarium Micro Guide eyepiece with marking similar to a Celestron Micro Guide eyepiece. A large difference was found compared to WDS due in part to a smoky sky, an incoming storm, and the novice level of the team members, who had a difficult time reading the labels on the eyepiece.

Introduction

A team of students (shown in Figure 1) made observations and took measurements of the double star β Scorpii at a three-day Apple Valley Double Star workshop that was held by the High Desert Astronomical Society (HiDAS) and the Antelope Valley Astronomy Club at the Lewis Center's Luz Observatory in Apple Valley, California on July 17, 2015. On the night that the observations were made, the sky was clear, except for there being some smoke visible in the western sky, which had a slightly negative effect on the quality of observations.

In the Washington Double Star Catalog (WDS, 2015), β Scorpii is identified as H 3 7AC. The right ascension and declination are listed as 160526.23-194819.4. The magnitudes of the primary and secondary stars are 2.59 and 4.52 respectively.

Figure 1: Team members from left to right: Ruth Schlosser, Bill Spreng, Jeff McCarthy, Sean Gillette, Alana Brown, Breauna Rhoades, and Benjamin Funk.

Equipment and Procedures

The telescope used was a Celestron C8 Schmidt-Cassegrain telescope (Figure 2) equipped with a 12.5mm Baader Micro Guide astrometric eyepiece, and

mounted on German equatorial. The drive system was a Celestron Advanced VX. A 2x Barlow lens was used.

To determine the scale constant, the observers focused the telescope on γ Cassiopeiae, or Navi, in the constellation Cassiopeia. They aligned this star on the linear scale of the Micro Guide eyepiece and turned the drive motor off, allowing the star to drift along the linear scale. Once the star reached the beginning of the scale, a stopwatch accurate to the nearest hundredth of a second was started. The observer watched the star drift and alerted the other team member to stop the watch once the star had drifted off of the scale. This was repeated twelve times to reach an average, standard deviation, and standard mean of the error.

The following equation was used to determine the scale constant:

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

where Z is the scale constant in arc seconds per division; 15.0411 is the Earth's rotational rate in arcseconds per second, t is the average drift time in seconds, dec is the declination of the calibration star in degrees, and D is the number of division marks on the linear scale (60).

The team then aligned β Scorpii along the linear scale and counted the tic marks between β^1 and β^2 to find the number of separation divisions. This was repeated 10 times for an average, standard deviation, and standard mean of the error.

The observers positioned the primary star on the center of the linear scale and turned off the drive motor, allowing the star system to drift to the inner protractor. The drive motor was turned back on and the position angle was recorded to the nearest half degree. The process was repeated 10 times to determine an average, standard deviation, and standard mean of the error.

Observation and Analysis

Observations were completed (B2015.54074) from the Lewis Center for Educational Research in Apple Valley, California between the hours of 9 PM and 11 PM, on Saturday, July 17, 2015. The evening temperature was approximately 80 degrees and the sky conditions were good but with smoke in the western sky that had a small impact on the observations. The completed observations were made during a waxing crescent moon that had not yet risen and with low light pollution.

Figure 2. The telescope used by the observers - Celestron C8 Schmidt-Cassegrain with Advanced VX Mount

Conclusion

The team found a scale constant of 4.56 arcseconds per division mark with a standard deviation of 1.19. The observer's average separation division was 15.3 arcseconds which was a percentage difference of 14.1% off from the WDS observations. The team found a position angle of 14.3° which was 30.8% off from the WDS observations.

The difference between our measurements and the published values was greater than the observers antici-

Table 1: Observations on Double Star System β Scorpii. All measurements made on 2015.542.

Parameters	# Obs	Mean	SD	Standard Error of Mean	WDS Value	Difference	% Difference
Scale Constant a.s. / division	12	37.17	1.19	0.34	NA	NA	NA
Separation (a.s.)	10	15.4"	0.50"	.16"	13.4"	1.9"	14.1%
Position Angle (degrees)	10	14.3°	6.92°	2.19°	19°	5.87°	30.8%

pated. This may have been because the observers had a difficult time reading the labels on the Micro Guide eyepiece, as well as the novice level of many of the team members.

Acknowledgements

The observers would like to thank Mark Brewer, the High Desert Astronomical Society, and the Antelope Valley Astronomy Club. The observers would also like to thank the Lewis Center for Educational Research for letting us use their facility, Walmart for their gracious donations, and Starbucks for their food donations. Special thanks goes to Tom Frey and Joseph Carro for external review of this paper.

References

Mason, Brian D.; Hartkopf, William I.; Tokovinin, Andrei, 2010, "Binary Star Orbits. IV. Orbits of 18 Southern Interferometric Pairs", *The Astronomical Journal,* **140**, 735-743.

Washington Double Star Catalog, 2015, Retrieved from http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/WDS