Astrometric Measurements of Multiple Components of the Double-Star System WDS 14246+4750

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Abstract

The multiple star WDS 14246+4750 was observed using Las Cumbres Observatory Telescopes to measure the position angles and separations of three separate double star components AB, AC, and BD. The position angles and separation components AB were found to be 181.32 deg and 6.35," and that of the AC was measured to be 65.3 degrees and 43.1". An attempt to measure the BD component was unsuccessful.

1. Introduction

The current research project was part of the Astronomy 295 class that was offered to Early College students from the Waipahu High School during the Spring 2021 semester. The purpose of this project was to afford hands-on experience in learning how astronomers experimentally determine the mass of stars. The objective of the research program was to choose an ideal double star candidate from the WDS Catalog, which has been officially cataloging valuable double star data since 1963.

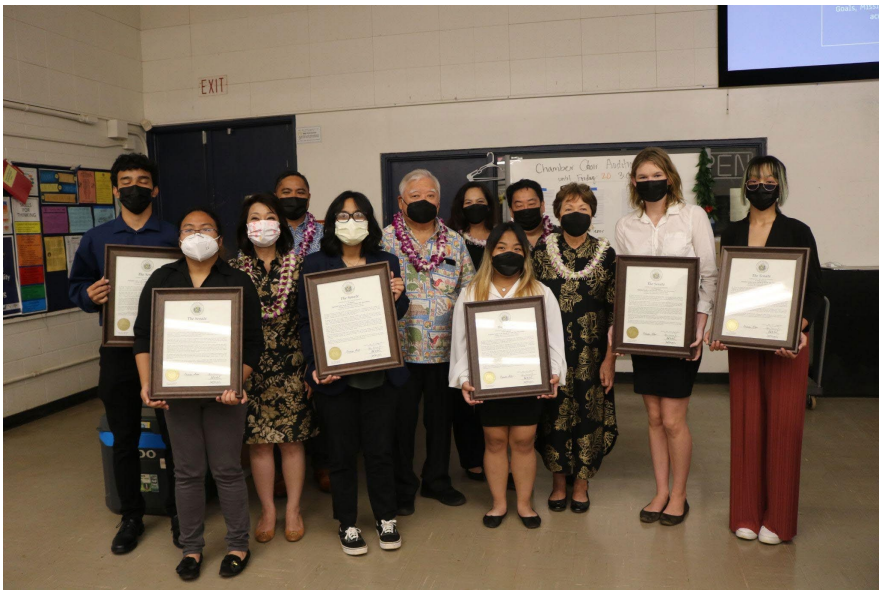

Figure 1. McInerny Foundation Early College Astronomy 295 team students and Hawaii Legislators (left to right): Zachary Tamoba, Alyssa Salcedo, Rep. Sylvia Luke, Rep. Henry Aquino, Lyra Dasalla, Senator Clarence Nishihara, Rep. Luella Costales, Tracie Kalena Kay Domingo, Rep. Ryan Yamane, Senator Michelle Kidani, Ava Thompson, Li Yang Fairman

The formation of our research team began as a remote, distance learning pilot project between two sister-Early Colleges High Schools (i.e., Odyssey Early College located in Colorado Springs, Colorado, and McInerny Foundation Early College High School located in Waipahu, Hawaii). Both student cohorts met regularly by Zoom teleconference during the 2021 spring semester as we engaged in research through the aegis of an Astronomy 295 class hosted by Leeward Community College. The research team consisted of six Waipahu students and six Odyssey students who for the most part were not science majors and who had little prior knowledge in the field of astronomy. In order to develop a foundation for the research, our instructor recommended that we refer to a seminal work by Russel Genet, et al., entitled *STAR: Small Telescope Astronomical Research Handbook* (2016). Unfortunately, the impact of inclement weather during the spring semester impeded timely astronomical observations and data collection. Moreover, the impact of the Coronavirus, unfortunately, took a toll on some of the Odyssey and Waipahu researchers, resulting in the need to suspend their participation in the project.

2. Equipment and Methods

TARGET SELECTION: Because there are thousands of double star systems from which to choose in the southern hemisphere, our first challenge was to consider suitable criteria necessary for double star selection. Since the class was held during the Spring 2021 semester, researchers focused exclusively on double star systems that were easily observable during the spring months. The researchers also considered other physical factors, such as the location of the observing site, altitude, telescope specifications, and double star characteristics such as magnitude or brightness differences between the pairs.

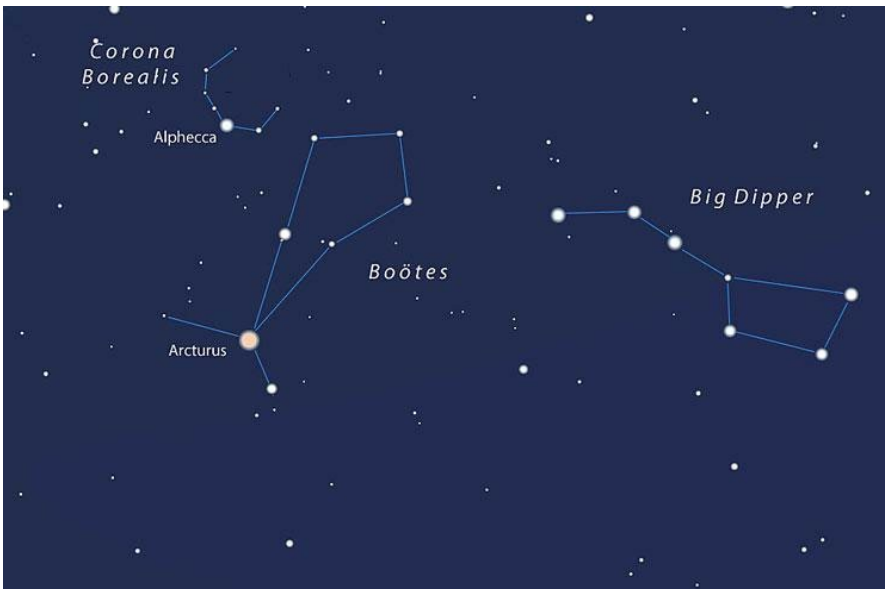

Figure 2. Location of the current double star system in the constellation of Bootes. Photo Credit: https://stellarium-web.org/p/observations

With these criteria in mind, the researchers selected an interesting double star system located within Bootes, and which was suspected of being a gravitationally-bound triple star system. In the Washington Double Star (WDS) catalog, this pair is identified as WDS 14246+4750 and is located at the top center within Bootes as shown in Figure 2.

This triple star system has historically identified each component as AB, AC, and BD. The primary stars labeled A had a magnitude of 7.68, while B and C had a brightness with a delta value of three or less. Unfortunately, however, the D component had a visual magnitude 17.76 and a delta magnitude of 8.53, which posed a challenge for the present observational runs due to its relative faintness.

HISTORICAL PERSPECTIVE: The first observations on the current double star system were performed by J.F. William Herschel in 1830 and the latest observation was carried out by Courtot, J.F. in 2018. During this period of 188 years, the AB component showed (187^0 - 186^0) 1^0 shifts in the assumed orbit with a separation (19.8 - 15.0) 4.8 arcseconds. The AC component changed, 67^0- 63^0 = 4^0 with a separation (92.4 - 100.8) = 8.4 arcseconds.

INSTRUMENTATION AND OBSERVING METHODS: The Research Team contacted scientist Dr. James D. Armstrong at the Institute for Astronomy on Maui and requested his help with observing and data collection. Dr. Armstrong is a Maui Technology Education and Outreach Specialist who works with the University of Hawaii on Maui.

The observations came from the McDonald observatory of the 0.4-meter network of the Las Cumbres Observatory[6]. The observations were made on April 12, 2021 and images were acquired using a SSC camera with an exposure time of 5 seconds, and an ip filter. 16 images were obtained, from which 12 images were culled for analysis.

Figure 3. Las Cumbres Observatory 0.4-meter Telescope Faulkes Telescope North Haleakalā Observatory. Telescope style: Cassegrain reflector optical telescope, Ritchey-Chretien telescope atop Haleakala (3,055m) Maui County. Hawaii, USA.

DATA REDUCTION METHOD: For purposes of data reduction, the authors used an application called AstroImageJ - an image analysis tool for astronomy written by Karen Collins and John Kielkopf of the University of Louisville. After downloading the data file into AstroImageJ, the image was solved using astrometry.net. Once the loaded image field was plate solved, the authors determined the Position Angle (Theta) and Separation (Rho) of the double stars. To render the data reduction, it was necessary to have a mouse with a wheel. First, by clicking on the center of the primary star and then holding the center wheel of the mouse, the authors moved the cursor to the center of the secondary star of interest. Then, the user gently released the anchor point of the wheel on the mouse in order to obtain the detailed position and separation data of the star components. The above process was repeated for both AB and AC components, after which the statistical averages were determined.

Figure 4A: Raw image of the Double Star Field with the brightest star being the primary star, A. The star next to the primary A is the B component and the bright star on the right is the C component. The third component star D is not visible for being very faint.

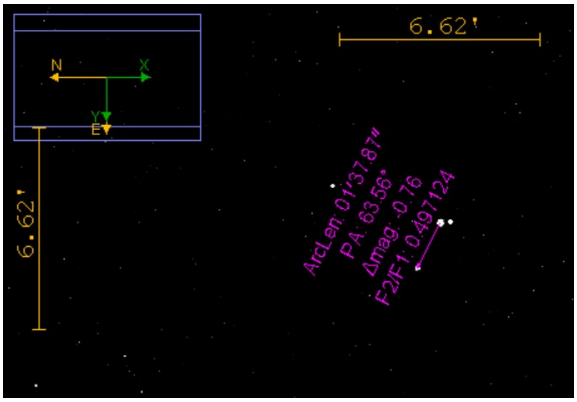

Figure 4B: A screenshot of AstroImageJ showing an illustration of the Position Angle and Separation, along with the orientation and dimension of the image.

3. Data

The Data Reduction of the AB and AC components using AstroImageJ are provided in Table 1 below. Separations of each component in Arcsecs (Rho) and the Position Angle (PA) in degrees are also noted below. Statistical average and standard deviation from the mean are presented. The third component (BD) was also in the images, but its magnitude was too faint for data analysis.

4. Discussion

The present results indicated that the Separation of the AB component was 19.49 arcsec and the Position Angle was 186.70 degrees. Compared to the previous reading, the position angle increased by 0.7 degrees, while separation decreased by 0.31 arcsec. The AC component had a Separation value of 99.01 arcsec and the Position Angles was 63.39 degrees. The results from the current data collected indicated a slight change in both Position Angle and Separation, as well as appearing to be a gravitationally-bound pair.

#	AB Rho (arcsec)	AB PA (degrees)	AC Rho (arcsec)	AC PA (degrees)
1	19.6961	186.2268	97.9700	63.3157
2	19.1551	185.8701	99.5900	63.0117
3	19.6000	187.9785	96.9420	63.9280
4	19.6992	186.6915	100.029	62.7260
5	19.6618	186.0607	100.2853	63.0256
6	19.29528	187.0932	98.3019	63.9012
7	19.8608	187.7191	99.0603	63.7612
8	19.1456	187.3868	99.8414	62.9958
9	19.2768	186.2662	97.9375	63.8229
10	19.60428	186.4227	99.3722	63.7153
11	19.3444	186.6394	98.5697	63.6199
12	19.5475	186.0726	100.2626	62.9499
Avg.	**19.49057**	**186.7023**	**99.01349**	**63.3977962**
Stdev.	**0.236845**	**0.693029**	**1.070204**	**0.43751368**
Sem	**0.068371**	**0.20006**	**0.308941**	**0.12629932**

Table 1: Table indicating Separation and Position Angles of suspected double star components AB and AC. Corresponding statistical results are also indicated.

5. Conclusion

The purpose of this research was to learn about double stars, their properties; and collect data on position angles and separations of a three-pair double stars system labeled WDS 14246+4750 [STF 1843], gain experience in scientific research, while at the same time reveal if the star system was a binary star or an optical pair. After data collection and analysis, the research team observed similar results as documented by previous observational results. As a result, the authors were not successful in concluding that the pairs' orbits represented a binary star or an optical pair. Further investigation is necessary to determine conclusively whether the pair is a binary star.

Star with ID STF 1843 is suspected to be a triple star system. The system AB and AC components show binary characteristics from the current data, while pair BD was inconclusive due to a lack of data and a very dim companion. Analysis of the current data was insufficient to conclusively prove that the BD components

were a gravitationally-bound pair. Further extended observational data may be required to conclusively determine the nature of their true orbits.

Acknowledgments

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