Measurements of double Star System WDS 17298-3232

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Abstract: We performed astrometric measurements on the double star WDS 17290-3232 (PRO 166), using images taken by the Las Cumbres Observatory telescope network (LCO). We found a difference in the WDS database proper motion for the system and the GAIA catalog. The calculated the theta and rho of the system was measured to be 355.76° and 18.06" respectively. The data suggests PRO 166 may be gravitationally bound.

Introduction

This study researched a double star to review evidence as to whether the system may be gravitationally bound. Selection of a candidate was reached by inspecting historical data of the secondary star's position angle (θ) and separation (ρ), comparing both stars' proper motion, and considering the differences in parallax of the stars.

Our team selected the candidate based on the following characteristics: a magnitude brighter than 13, a separation greater than 5 arcseconds, a right ascension between 12 and 18, and no observations since 2000. The magnitude and separation criteria were necessary due to the resolution of our telescope and CCD equipment. The right ascension criteria ensured we could observe the system in the spring. Ensuring there were no observations since 2000 made sure the measurements would update historical data. The following were used to select the system and to provide historical data: the Washington Double Star Catalog (WDS) by Brian Mason (2018), images in Aladin Sky Atlas V10.0 using GAIA Source DR2 data and Simbad Astronomical Database data, and Dave Rowe's WDSGAIA DR2 V2 (Harshaw 2018) excel spreadsheet.

We chose the star system WDS 17298-3232 PRO 166 because it fit all the aforementioned criteria. Its last observation was from 1999, so new observations could help clarify the nature of the double star system by updating the historical data and contributing new data, including parallax and new proper motion. Clive Nossiter first observed this system in 1911 with a position angle of 355 degrees (Theta) and a separation of 18 arcseconds (Rho). Nossiter reported a magnitude of 10.4 and 10.7 for the A and B star, and infrared surveys such as the 2 Micron All Sky Survey and Deep Near Infrared Survey of the Southern Sky, and the Astrographic Catalog 2000 reported both stars to have magnitudes between 11 to 12.

Although the discoverer of PRO 166 was listed as Nossiter in the WDS (Nossiter, 1913), other sources suggest that others played a bigger role in the discovery. According to records from the Perth Observatory, Nossiter worked with four young women "computers", Ethel Allen, "Minnie" Harvey, Ida Tothill, and Prudence Williams, who catalogued and measured hundreds of individual stars, and identified phenomena such as double stars (Nossiter, 1913). Williams alone was responsible for the re-measuring of all stars which required it (Nossiter, 1913), and she was the most vocal on the matter of recognition and pay for the women because they felt they did much of Nossiter's computational work for him (Williams, 1914). Though the women actually identified the systems for Nossiter to report, Nossiter did not credit these women in his paper on newly discovered double stars.

Methods and Materials

All images were taken by the telescopes of the Las Cumbres Observatory on April 3 and 16, 2020. Due to the system's declination of -32 degrees, the team used telescopes in the southern hemisphere. Each telescope features a diameter of 0.4 meters and a SBIG STX 6303 camera. These cameras have a resolution of 0.57

Received July 27, 2020

arcseconds per pixel, with a total field of view of 19.5 by 29.2 arcminutes. Twelve images were acquired using the Sloan RP filter. Each were plate solved and calibrated in the OSS pipeline (Fitzgerald), then analyzed using the program AstroImageJ (AIJ), Figure 1, finding the position angle, separation, and difference in magnitudes. The team measured each image twice to avoid human error and then calculated the mean, standard deviation and standard error of the mean to determine the uncertainty of our measurements.

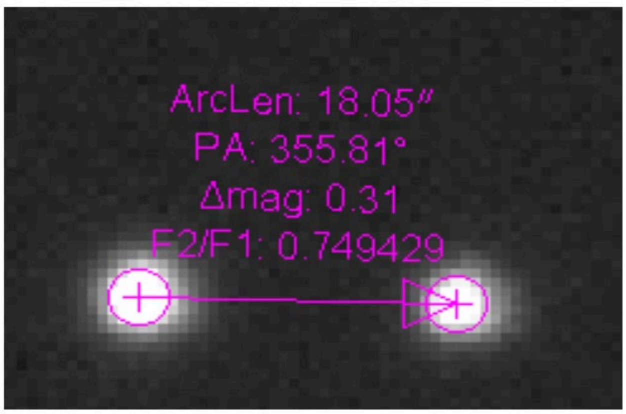

Figure 1: Image of PRO 166 in AstroImageJ during measurement

Results

Our astrometric measurements for PRO 166, Table 1, are presented with the mean and standard error. We calculated the delta magnitude at 0.337±0.009, the separation at 18.061±0.023 arcseconds and the position angle at 355.761±0.074 degrees. The difference in magnitude is similar to the original measurements (Nossiter, 1913). The standard error of the mean and the last measurement were added to the table for reference.

WDS 17298-3232 PRO 166 Measurements (12 images)	Mean	Standard Deviation	Standard Error of Mean	Epoch	Last Measurement from 1999.268
Delta Magnitude	0.34	0.009	0.002	2020.292	0.30
Separation(arcseconds)	18.06”	0.023	0.005	2020.292	18.032”
Position Angle(degrees)	355.76°	0.074	0.015	2020.292	355.9°

Table 1. PRO 166 Astrographic Measurements

Discussion

Our measurements were used to update a historical graph in an effort to find evidence of an elliptical path indicating the possibility of an orbit. We compared the historical measurements in light of the methods used at that time. Some of the past measurements, however, did not have a written record of their methods. These measurements were included, but we marked those values.

We plotted the θ and ρ values for each year recorded on a Cartesian graph tool created by Richard Harshaw, Figure 2. The primary star is located at the origin of the graph, and all other data points represent the location of the B star in relation to the A star. Position angle and separation determined the X and Y-coordinates for each point: the position angle is represented with a counter-clockwise measurement from the North axis to the individual data point, and the separation is the distance in arcseconds from the origin to the individual data point. Figure 2 shows no discernable movement consistent with an orbit of the B star around the A star. In Table 2, in the table in which we recorded the theta and rho from each measurement and the quality of the measurement, we see no defined pattern of movement over time. Because the B star does not seem to move significantly, the fluctuations in measurement processes, or minute movements over time, might just be part of the margin of error as opposed to actual movement. Since the graph

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and table do not show enough definitive movement to show an orbit or lack thereof, we cannot use this in our conclusion.

As shown in Figure 3, a proper motion picture taken in Aladin10 from the GAIA coordinates of PRO 166, show similarities between the two. Within the WDS database, the proper motions show different values from Aladin/GAIA, Table 3. The proper motion in the GAIA database was used for all proper motion analysis in this paper. Using this data, we calculated the Harshaw statistic, a number that leans on the proper motions of the two stars, as 0.047392 from the paper, "Another Statistical Tool for Evaluating Binary Stars" (Harshaw, 2014). Due to the number being close to 0, the Harshaw statistic indicates they are likely to be moving together, which suggests the two stars maybe gravitationally bound common proper motion stars.

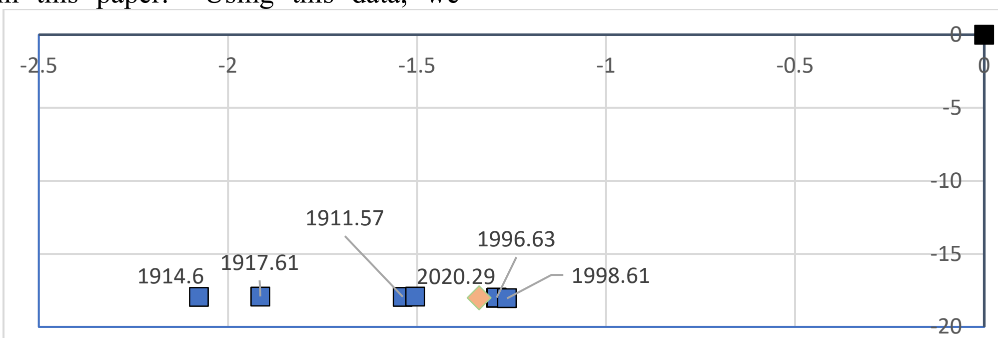

Figure 2. Cartesian graph of theta vs rho over time

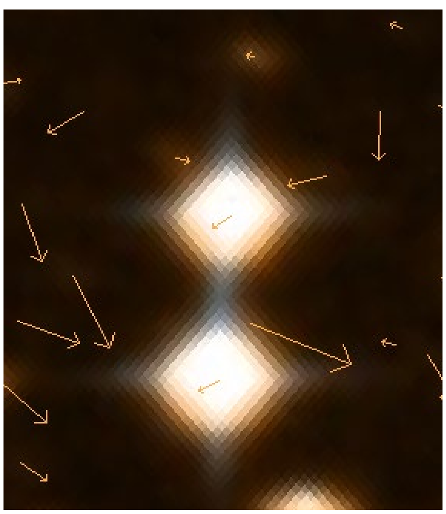

Figure 3: Aladin 10 image with a filter showing GAIA proper motion data

Proper Motion PRO 166	A Star		B star	
WDS Database	+008	+003	+004	-001
GAIA Database	+002	-001	+002	-001

Table 3. Proper Motion Differences between GAIA and WDS.

To further analyze this, we calculated the mean distance from the stars to Earth using parallax data from the GAIA database, Table 4, with results outlined, Table 5, showing the range of distances within one standard deviation of the A star and the B star based on the GAIA error. We calculated the normal distribution of the distance between A and B to find the likelihood that they are within 1 light year, or 0.306601 parsecs, considered to be the maximum distance for two stars to be gravitationally bound (Reipurth, Mikkola, 2012). The chance the stars lie within 0.306601 parsecs is 0.3 percent. We calculated the current closest distance based on parallax and separation to be within 0.315 and 0.349 light years and 0.097 to 0.107 parsecs, which means it is possible for the system to be within 1 light year of each other. We suggest future research focus on getting a parallax measurement with a smaller error bound for this system.

	A Star	B Star
Parallax	0.861192649	0.879122952
Error	0.043850261	0.039892086

Table 4. Parallax Data for PRO 166 from GAIA DR2

	Distance from Earth in Parsecs		
	Mean– σ	Mean	Mean + σ
A Star	1104.92	1161.18	1223.48
B Star	1088.12	1137.50	1191.57

Table 5. PRO 166 Distance from Earth +/- 1 standard deviation

Conclusion

We measured θ and ρ for system PRO 166. We found discrepancies between the WDS proper motion, +008+003 +004-001, for the system and the GAIA database of, +002-001 +002-001. Overall, the data suggests the B star has not had any significant movement in comparison with the A star. The Harshaw statistic, referencing proper motion, however, implies the stars are moving together, a sign of gravitational interaction. Thus, we cannot conclude PRO 166 is gravitationally bound.

Acknowledgements

We would like to thank the Washington Double Star Catalog, the United States Naval Observatory and specifically Brian Mason for providing historical information on the chosen double star candidates, and for a catalog of double stars to select from. We appreciate Michael Fitzgerald's work in plate solving our images in the OSS pipeline. We thank Bob Buchheim for creating the mathematical model to determine the probability the stars are gravitationally bound by using parallax. We thank Richard Harshaw for creating the plotting tool and the proper motion model we used. We would also like to thank the Boyce Research Initiatives and Education Foundation (BRIEF) for providing the remote server and the software needed, and for making this opportunity possible. Additionally, we would like to thank the Las Cumbres Observatory telescope network for generously donating their telescope time to us. Additionally, this paper would not be possible without the assistance, contribution and feedback of our mentors, Francesca D'Amico and Cassidy Sullivan. Lastly, we would like to thank Pat and Grady Boyce for hosting the online lessons which guided us along the process of writing the paper, and for additional guidance and feedback. This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation.

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