Astrometric Calculations Indicate That 14171+0103 HJ 1250 is Physical Double

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Abstract

We performed astrometric measurements on the double star system WDS 14171+0103 (HJ 1250) through CCD images and measured a position angle of 4.344°, and a separation of 18.753 arcseconds. Utilizing parallax and proper motion data, we concluded that the HJ 1250 star system is a likely a physical double.

Introduction

Our goal was to measure the current position angle and separation for the stars of this star system utilizing CCD imaging. In addition, we intended to find evidence indicating whether the star pair was a physical double star using the stars' proper motion vectors and parallax data to determine if the stars are moving together and if the stars are close enough to be gravitationally bound. We hope to contribute to the further research of these stars by presenting the latest astrometric data measurements for this star system.

The star pair being studied, 14171+0103 HJ 1250, was discovered in 1828 by Sir John Fredrick Herschel. While searching for candidates, we considered the following criteria in our decision:

- Possessing a delta magnitude less than 3
- Brightness greater than 12 magnitude
- Separation no less than 5 arcseconds
- Similar proper motion vectors
- Not recently measured

One additional criteria we considered was the proper motion vectors for stars under consideration. Once we had selected candidate stars, we used Gaia DR2 data to narrow down our choices to candidates with similar proper motion vectors.

Since its discovery, there have been a total of 26 recorded observations of this pair. The latest astrometric data of this star pair follow the guidelines we used. The primary star is a G5 spectral class star with a magnitude of 9.47 and right ascension of 14h 17m 07.19s and declination of 01° 03' 13.3". The secondary star has a magnitude of 10.31. The first separation measured in 1828 was 15.0 arcseconds with a position angle of 12°. The most recent measurement obtained from Gaia DR2 in 2015 by El-Badry and Rix, showed a separation of 18.74 arcseconds and a position angle of 4.337°.

Materials and Methods

All the images used to perform measurements were taken using two 0.4m telescopes from the Las Cumbres Observatory. These telescopes utilize SBIG CCD cameras to provide an image resolution of 0.571 arcseconds per pixel and a field view of 29' by 19.' For our observations, we used a clear filter and an exposure time of 5 seconds. We collected a total of 12 images on 2 dates. We obtained 2 images using a telescope in Sutherland, South Africa on April 6, 2021 and 10 additional images using a telescope in Chile on April 9, 2021.

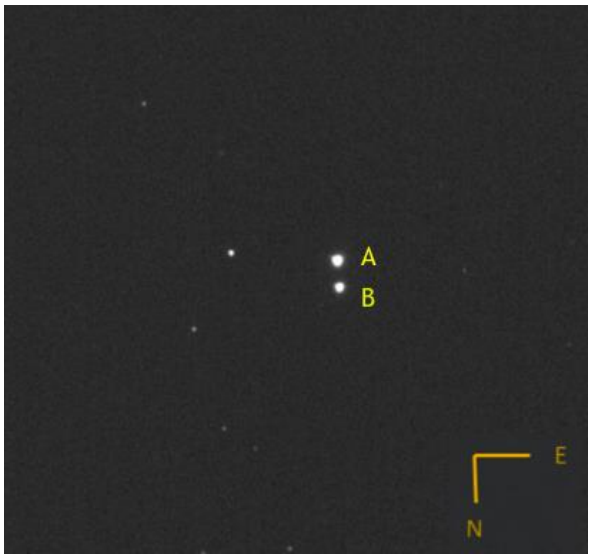

Figure 1: Sample image of HJ1250

The images from the Las Cumbres Observatory were processed and calibrated using the Our Solar Sibling pipeline (OSS). Once the images were received, we used AstroImageJ to measure the distances between the primary and secondary stars and their position angles. Image measurements were conducted by two members of our team utilizing the built-in centroid calculation capability of AstroImageJ to get the highest accuracy and remove any systematic errors that could occur if measured by a single team member. Once all images were measured, we calculated the mean, standard deviation, and standard error of the mean.

Results:

The astrometric measurements for epoch 2021.271 are shown in Table 1 below. We calculated a mean separation angle of 18.75 arcseconds and a position angle of 4.34 degrees.

Table 1: WDS 14171+0103 HJ1250 Angle and Separation Measurements

WDS 14171+0103 HJ 1250 Measurement Results				
Telescope, images, filters	**Epoch 2021.271**	**Position Angle (deg)**	**Separation (arcsec)**	**Delta Magnitude**
LCO (kb29),10, air	Mean	4.356	18.752	0.767
	Std. Dev.	0.035	0.023	0.007
	Std. Error	0.011	0.007	0.002
LCO (kb84), 2, air	Mean	4.282	18.752	0.749
	Std. Dev.	0.088	0.026	0.022
	Std. Error	0.062	0.008	0.016
Combined Data	Mean	4.344	18.753	0.764
	Std. Dev.	0.041	0.023	0.009
	Std. Error	0.012	0.007	0.003
Last Observed (Epoch 2015.5)		4	18.7	N/A

Discussion:

We found a great deal of information about the stars of this pair from the Gaia DR2 dataset, including very accurate values for the parallax measurements and proper motion measurements. These data are presented in Table 2 below. This information was beneficial in further determination of the likelihood that these stars do, in fact, form a physical double system.

Table 2: Parallax and Proper Motion Data for HJ 1250 from GAIA DR2

	Parallax Value	**Parallax Error**	**Proper Motion: RA**	**Proper Motion: DEC**
Primary Star	11.1482	0.0155	50.244	-104.855
Secondary Star	11.1303	0.0139	51.42	-103.906

Utilizing parallax data acquired from Gaia DR2, we calculated a distance of 292.42 light years to the primary star and a distance of 292.89 light years to the secondary star. With a separation angle of 18.75 arcseconds, we calculated the closest separation possible in the plane orthogonal to our line of sight at the time of the observation to possess a distance between the stars of 0.042 light years or 2656 AU. Further utilizing the parallax data and error estimates in the Gaia DR2 dataset, we calculated an 83% probability that the stars are within one light year of one another in the radial distance. This small separation distance is certainly within expectations of a physical double star pair.

To further determine whether these stars form a physical double, we used the proper motion data from the Gaia DR2 dataset to calculate the Harshaw Statistic, the ratio of the vector difference to the vector sum, to compare their relative proper motions. The resulting value of 0.0065 strongly shows that the proper motions of these stars are nearly identical and is highly indicative that the stars are moving together. Figure 2 below is a graphical representation of the star's proper motion provided by Aladin 10 software utilizing the data from Gaia DR2 to plot motion vectors. This similar motion and close proximity of these stars is a strong indication that the star system HJ1250 is a physical double.

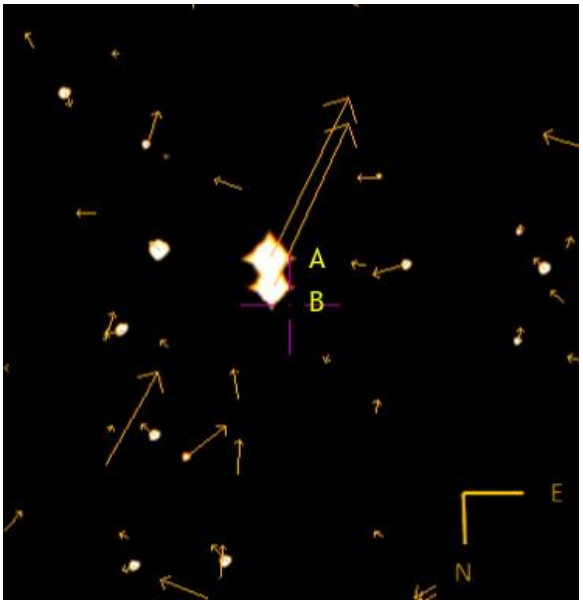

Figure 2: Aladin 10 measurement of Proper Motion Vectors utilizing Gaia DR2 proper motion data

Finally, our team drew up a representation of a historical data plot to visually represent the progression of our star system's movement. The data point labeled 1828 is the first measurement made when discovered. Subsequent measurements are shown in the grouping of data points in the lower left portion of the plot. The measured data presented in this paper are labeled with the label 2021.271 representing the date when our images were acquired.

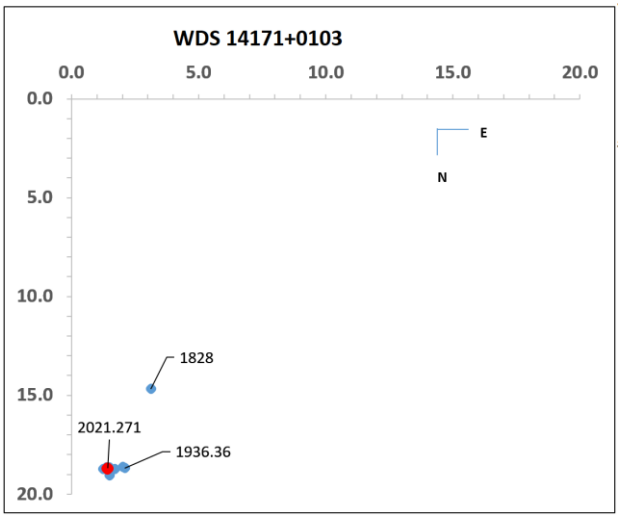

Figure 3: Historical measurements for HJ1250

Conclusion:

We obtained astrometric measurements of the double star system 14171+0103 HJ 1250 through images acquired by the Las Cumbres Observatory telescope network (LCO) and were able to analyze data and calculate the current proper angle and separation of the stars of this system. In terms of radial distance, we calculated a high probability of the A and the B star being within one light year of one another and by use of the Harshaw Statistical calculator, found their proper motion vectors to be very close. Furthermore, these calculations, along with Gaia parallax measurements, indicate that the two stars are less than 1 light

year apart in the plane orthogonal to our line of sight at the time of the observation. These data indicate an a very high likelihood that the two stars of HJ 1250 form a physical double pair. We recommend that a 'T' note be attached to the historical data in the Washington Double Star Catalog to indicate that this star pair is a physical double.

Acknowledgements:

We would like to give a special thanks to Pat and Grady Boyce of the Boyce Research Initiatives and Education Foundation (BRIEF) for aiding us throughout the entire process of this paper. We would additionally like to acknowledge and offer thanks to our mentor, Mr. Allen Priest for guiding and supporting us throughout the course of our research and we owe our sincerest gratitude to Brian Mason at the Naval Observatory for providing us with the historical measurements. Finally, we thank and appreciate all who funded and provided us with materials throughout this research process, including: Michael Fitzgerald for the OSS Pipeline image processing, Bob Buchheim for his radial distance probability method, all those at the Las Cumbres Observatory who provided us with telescopes through which to view our stars and perform our calculations, and Richard Harshaw for the historical data plotting tool and proper motion statistical calculation.

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