Measurement of the Rarely Observed WDS 13208-0431 BRT 446

Leena Iwamoto[1], Nora Dunphy[2], Mansi Sharma[3], Hilde van den Bergh[4], Pat Boyce[4], Grady Boyce[4]
[1] Mt Everest Academy, San Diego, CA
[2] Mt Everest Academy, San Diego, CA
[3] Scripps Ranch High School, San Diego, CA
[4] Boyce Research Initiatives and Education Foundation (BRIEF), San Diego, CA

Abstract

We report the astrometry of the double star system, WDS 13208-0431 (BRT 446), which was observed with the LCO global telescope network. The position angle and separation between the components were measured, reported, and compared with previous observations and measurements. Resulting measurements include a theta of 296.08° and a rho of 14.73". The data we acquired, compared with the historical and Gaia data, suggests this pair is non-physical.

1. Introduction

The selection criteria for WDS 13208-0431 from the Washington Double Star Catalog (WDS) required it to be a rarely observed system, a magnitude no less than 9 but no higher than 14, a separation greater than 5", and system observable during the springtime. WDS 13208-0431 (BRT 446) satisfied these criteria. The purpose of this research was to measure the system, update records on a rarely observed pair, and determine the nature of the pair.

WDS 13208-0431 was first measured by Dr. Samuel G. Barton, Fig. 1, in 1909. Historically, this system was observed twice in 1909 and once in 2019, with a total of three observations, Table 1.

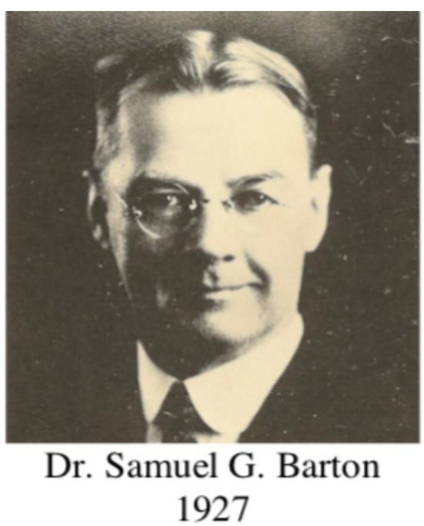

Figure 1. Discoverer Samuel Barton.

Epoch	Theta (degrees)	Rho (arcseconds)
1909.43	275.4	4.5
1909.44	275.5	4.399
2019.33	296.9	14.47

Table 1. WDS 13208-0431 Historical Data.

2. Equipment and Methods

We used Washington Double Star Catalog, Stelle Doppie, SIMBAD, the GAIA Archive, Palomar Sky Survey, and Aladin10 to collect information and visualize the system. The 1958 Palomar Sky Survey was used to obtain a historical image of our system. To acquire images, we remotely employed the LCO McDonald Observatory 0.4m telescope with SBIG 6303 CCD camera. First, we submitted our test images using the Sloan g, r, l, and u filters each with an array of exposure times. Determining the best set of parameters, we selected the Sloan r filter with a 25 second exposure time for our images, Figure 2. From our images, AstroImageJ was used to find the overall mean of the theta and rho measurements, Table 2, with the standard deviation and standard error of mean for each value, reported in Table 3.

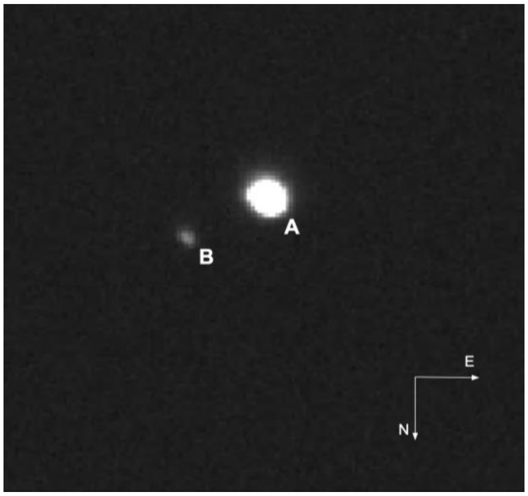

Figure 2. Science image.

3. Data

Measurements of our images had mean values of theta as 296.08°, rho as 14.73", and difference in magnitude of 4.76, Tables 3 and 4. Through the Aladin10 software, we used the Gaia 2015 Sky Survey images to derive the values of theta as 296.5° and rho as 14.89" which we compared to our science images' data values. Inputting parallax data into a distance calculator, we also determined the mean distance to star A as 2772.38 parsecs and to star B as 1721.17 parsecs, Table 4.

Star	Epoch	Number of observation nights	Number of Measurements	Delta Magnitude	Theta (degrees)	Rho (arcseconds)
Primary (A Star)	2021.34	1	12	4.76 (Sloan r)	296.9	14.47
Secondary (B Star)	2021.34	1	12	4.76 (Sloan r)	296.6	14.89

Table 2. WDS 13208-0431 BRT 446 Data.

Telescope, Images, Filters	Epoch		Theta (degrees)	Rho (arcseconds)	Delta Magnitude
LCO (0.4 SGIB), 12, Sloan r	2021.34	Mean	296.08	14.73	4.76
	2021.34	Standard Deviation	0.35	0.07	0.08
	2021.34	Std. Error of Mean	0.1	0.02	0.02
		Last known measurements	296.9	14.47	N/A
		Gaia via Aladin 10	296.6	14.89	N/A

Table 3. WDS 13208-0431 BRT 446 Measurement Results.

Results	Parsecs		
	-1 Standard Error (SEM)	Mean	+1 Standard Error (SEM)
Star A	2603.49	2772.39	2964.72
Star B	1644.74	1721.17	1805.05

Table 4. Distance Calculation

4. Discussion

The earlier historical data collection includes both the last known 2019 measurements and Gaia sky survey 2015 measurements. Both historical data sets, compared with our final measurement results, are congruous. This leads us to conclude that the A and B stars have not moved over time. The Palomar Sky Survey image, Figure 3, was used as an alternative comparison medium to further verify any possible movement of our system over a larger time period. Comparing the Palomar image's field of view with our science images, WDS 13208-0431 shows little movement over the 63 years between each image, affirming our measurements.

Image 3. Palomar Sky Survey (1958) image.

We used Aladin10 to create proper motion vectors for both stars, shown in Figure 4. Star A has a relatively short vector that points South. Star B has a much longer vector that points Southwest. The significant difference in proper motion between star A and B leaves little possibility of being gravitationally bound, as proper motions are usually parallel and of similar lengths when a system is bound. The third arrow at the very top of star A represents proper motion of a star separate from our system and is excluded from analysis.

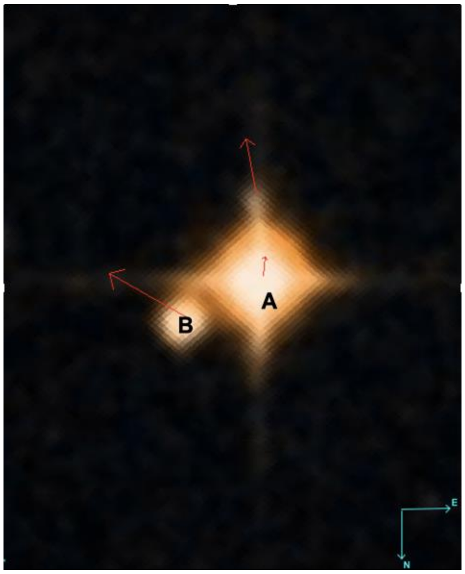

Figure 4. Gaia Sky Survey image with proper motion vectors.

Richard Harshaw, an astronomy researcher and author, published a method to determine the likelihood of a binary double using proper motion. This method results in the Harshaw statistic, ranging from 0 to 1. A statistic of 0 indicates a physical double, while a statistic of 1 indicates an optical double. Through his method, we calculated the Harshaw statistic for WDS 13208-0431 to be 0.76. This statistic indicates an optical double as the value is closer to 1 than it is to 0.

Parallax was used to calculate the average difference in distance to star A and B. The derived distance between both stars was on average 1,051 parsecs, previously noted in Table 4. This distance measurement is too large for our system to be physical.

Overall, the difference in distance between the stars is too high for binary classification. The variance between both stars' proper motion, along with the high Harshaw statistic of 0.76, also argues against gravitational attraction. This data accumulation leaves little possibility of a binary double classification.

Recent data suggests there may have been an error during initial data analysis in 1909. Historical theta measurements are relatively similar. However, there are large discrepancies between initial and current rho values. The discoverer used micrometer tools to obtain measurements. This discrepancy may be attributed to the large margin of error coinciding with micrometer equipment and methodology. Alternatively, the proper motion vector of star B may have increased the separation between stars, therefore an increased rho measurement over time, explaining the differences in rho values.

5. Conclusions

We determined the system WDS 13208-0431 is unlikely to be gravitationally bound through photometry, measurement, and analysis. Due to the large difference in distance, the likeliness of a physical system is low. The difference in proper motion and high Harshaw statistic enforce this claim.

The statistically different parallax and proper motion indicates that this pair is non-physical. This conclusion correlates with note "S" in WDS.

Acknowledgments

Our team would like to thank Pat and Grady Boyce for their guidance and support throughout the research process, along with our mentor Hilde van den Bergh for her assistance. In addition, we would like to thank Brian D Mason at the US Naval Observatory for the historical data on our stars and the Las Cumbres Observatory for providing observation services. Lastly, we would like to thank the Boyce Research Initiatives and Education Foundation (B.R.I.E.F.) for giving us the opportunity to research and publish this paper.

This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory. This work has also made use of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement."

References

Barton, S.G. 1935. *A Guide to the Constellations*. New York: McGraw Hill.

Fitzgerald, M.T. (2018, accepted), "The Our Solar Siblings Pipeline: Tackling the data issues of the scaling problem for robotic telescope based astronomy education projects.", Robotic Telescopes, Student Research and Education Proceedings

GAIA Astronomical Database Archive: Gaia Collaboration et al. (2020a): Gaia EDR3: Summary of the contents and survey properties Riello et al. (2020): Gaia EDR3: Photometric content and validation, Gaia Collaboration et al. (2020d): Gaia EDR3: The Gaia Catalogue of Nearby Stars;https://gea.esac.esa.int/archive/

Harshaw, R. (2018). Gaia DR2 and the Washington Double Star Catalog: A tale of two databases. Journal of Double Star Observations , 14(4). Retrieved from http://www.jdso.org/volume14/number4/Harshaw_734_740.pdf

Mason, B. and Hartkopf, W. The Washington Double Star Catalog, October 2015. Astrometry Department, U.S. Naval Observatory. https://ad.usno.navy.mil/wds/wds.html. Department, U.S. Naval Observatory.

Sordiglioni, Gianluca Stella Doppie, Double Star Catalog. Date Retrieved: 15 April 2021