An Investigation into Uncertain Double Star WDS 18494+5811 in the Draco Constellation

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Abstract: A diverse group of high school students from across the United States participated in a scientific research opportunity with the Institute for Student Astronomical Research in the summer of 2021. Astrometric measurements were taken of WDS 18494+5811 STI 2392 on July 13th, 2021, with a RA of 18^h 49^m 26.89^s and DEC of +58° 11' 07.5", and it was determined that the position angle of this binary pair was at 142.38 +/- 0.25 with a separation of 5.34 +/- 0.024. This binary pair was originally identified as being uncertain as a physically bound pair, at this time the data suggests that the system is at least a common proper motion pair but almost certainly physical.

Introduction

WDS 18494+5811 STI 2392 was first observed in 1903 by the Dutch astronomer Johan Stein, who studied astronomy at the University of Leyden, in the Netherlands. The first astrometric measurements recorded the separation at (ρ) 4.0″, with a position angle (θ) of 132° in 1903. The last recorded observation, before this publication, was in 2015 by the Gaia Survey mission, which recorded (ρ) 5.4″ and (θ) 141°. According to historical documents obtained from the United States Naval Observatory, to date, there have been a total of 16 recorded observations *(Table 2).* This system is located at a right ascension of 18^h 49^m 26.89^s, and a declination of +58° 11' 07.5". The primary star of this system has a magnitude of 10.40, the secondary star has a magnitude of 12.00 with a delta magnitude (**Δ**M) of 1.6. This system, located within the constellation Draco, has been identified as uncertain in the aspect of being a physically bound double star (Sordiglioni, 2020).

Equipment and Procedure

WDS 18494+5811 was selected by utilizing Dave Rowe's GAIA Double Star Catalog Selection Tool (version 1.02). Selection parameters were drafted based on the observational ability of the Las Cumbres Observatory's (LCO) 0.4-meter SBIG telescopes, and are listed in Table 1.

	RA	Dec	GMag0	GMag1	Δ Mag	Sep
Min.	14^h 00^m 00^s	-80° 00' 00"	10	10	0	5″
Max.	23^h 00^m 00^s	+80° 00' 00"	13	14	2	8″

Table 1: Parameters used to select a double star, separation measured in arcseconds.

Filtering the Washington Double Star (WDS) Catalog with these parameters resulted in 266 viable stars, which were cross-referenced with Stelle Doppie, the WDS search engine, to determine the gravitational nature of each star. Of these, WDS 18494+5811 was selected for its relatively long observational history and uncertain gravitational nature.

An observational exposure time of 2 seconds was calculated by use of the LCO Exposure Time Calculator using a magnitude of 10.4 and an S/N Ratio of 100. Two test exposures were taken with 1, 2, and 3 second exposure times and analyzed using AstroImageJ, which confirmed the original recommendation of the calculator. Ten final images were requested from the LCO and their network of telescopes around the world, with a 2-sec. exposure time. The LCO portal located at the McDonald Observatory, in Fort Davis Texas, was the first available telescope that could take the requested images. Using the site's 0.4-meter telescope, which was modified with custom equatorial C-ring mounts (Figure 1), and a CCD imaging SBIG STL-6303 camera, a total of ten images were taken on July 13, 2021. The position angle, delta magnitude, and separation of each of the ten images were then measured using the AstroImageJ software (Collins et al., 2017) (Figure 2) and reported in Table 1. Because the first image was visually abnormal and unmeasurable with an aperture of 4 arcseconds (unlike the other 9 images), it was excluded from the data set. Historical data was requested on July 8th, 2021 from Dr. Brian Mason, an astronomer at the United States Naval Observatory.

Figure 1: Las Cumbres Observatory portal node, located at the McDonald Observatory, in Fort Davis, Texas.

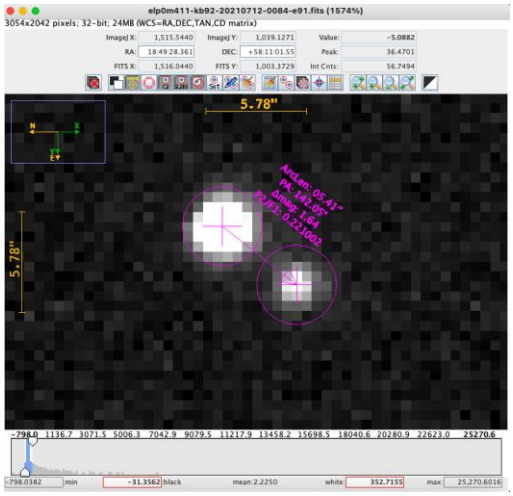

Figure 2: Screenshot of AstroImageJ interface, showing position angle and separation from the primary to the secondary star.

Results

Table 2 illustrates past measurements showing the position angle and separation of the binary pair over time, some data from 1903 was excluded due to incongruent results possibly stemming from the photographic measurement techniques used. Table 3 illustrates the measurements taken from all 9 acceptable images out of the 10 images taken. Figure 3 shows the separation of the primary star relative to the secondary star over time.

Epoch	PA (deg)	Sep (arc-seconds)	Measurement Type	Observer Code
1903	132.00	4.00	Pa G	WFC1998
1903.58	131.70	4.04	Pa G	WFC1998
1903.61	133.50	5.08	Pa G	WFC1998
1918.65	140.90	5.93	Mb B	ES_1919
1992.49	142.00	5.22	Ma A	Mlr1997
1999.37	141.80	5.52	E2 E2m	TMA2003
2003.61	141.50	5.35	Eu Eu3/4	UC_2013b
2006.7	140.60	5.37	C F	Dal2007
2012.44	141.64	5.48	Er	UR_2015
2013.48	141.33	5.35	Er	UR_2015
2014.46	141.40	5.35	Er	UR_2015
2015	141.42	5.36	Hg	Kpp2018m
2015.37	141.39	5.33	Er	UR_2015
2015.5	141.42	5.36	Hg	Gai2018

Table 2: Historical Data for WDS 18494 +5811, position angle (θ) *measured in degrees, separation* (ρ) *measured in arcseconds*

Image	PA	Sep
2	142.05	5.41
3	141.35	5.23
4	142.48	5.37
5	142.29	5.40
6	143.74	5.30
7	141.8	5.34
8	141.97	5.28
9	143.27	5.45
10	142.51	5.29
Mean	142.38	5.34
Std. Dev.	0.74	0.072
SEm	0.25	0.024

Table 3: Summary of separation and position angle data for WDS 18494+5811, measured in AstroImageJ. position angle (θ) *measured in degrees, separation* (ρ) *measured in arcseconds*

Discussion

Richard Harshaw's Plot Tool (Figure 3) shows a noisy distribution that makes an orbital path unclear; the GAIA EDR3 data (Table 4) shows similar parallax and proper motion values. This implies that while the physical nature of this double is uncertain, it appears to be at least a common proper motion pair.

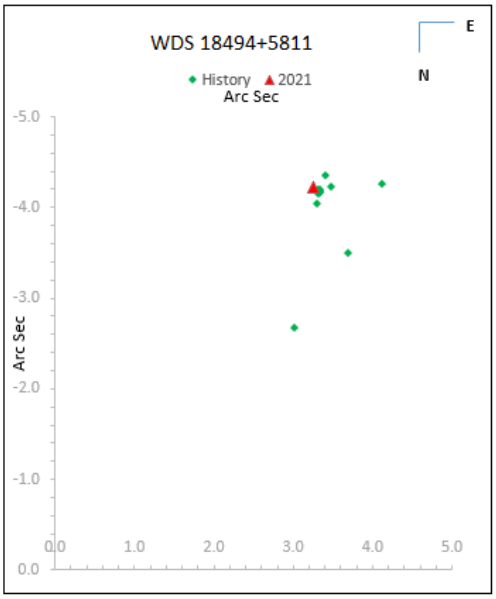

Figure 3. Historical Data plotted with Richard Harshaw's Plot Tool 3.19. A representation of the secondary star (plotted points) and its position relative to the primary star (origin) over observations. No clear orbital trend is visible. The red triangle represents the new data point.

Comp-onent	Parallax (mas)	RA Proper Motion (mas/year)	DEC Proper Motion (mas/year)
A	2.0655 +/- 0.0100	2.756 +/- 0.012	32.853 +/- 0.013
B	2.0630 +/- 0.0089	2.658 +/- 0.011	33.012 +/- 0.012

Table 4: Gaia EDR3 Data (Epoch=2016.0)

Conclusions

Using US Naval Observatory historical data and Richard Harshaw's Excel Plot Tool to graph the relative positions of WDS 18494+5811 demonstrates that more data is needed to conclude with certainty that this double is physical, as no visible arc is shown. Using Gaia DR2 data, which shows similar parallax and proper motion values for both stars, the calculations and data methods provided by Harshaw (2017) show an 88.44% chance of this double being physical in nature. However, running the same calculation with Gaia EDR3 data instead, an 89.82% chance of this double being physical, as the Gaia EDR3 data is more precise than the Gaia DR2 data. This information suggests that this double is a physical system but merits more study.

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References and Sources

Collins, K. (n.d.). AstroImageJVersion (3.4.0). AstroImageJ ImageJ for Astronomy. https://www.astro.louisville.edu/software/astroimagej/.

Collins, K. A., Kielkopf, J. F., Stassun, K. G., & Hessman, F. V. (2017). ASTROIMAGEJ: Image Processing and Photometric Extraction for ULTRA-PRECISE ASTRONOMICAL Light Curves. The Astronomical Journal, 153(2), 77–89. https://doi.org/10.3847/1538-3881/153/2/77

Daily, J. A. (2006). Notes on the Double Stars of Father Johan W. Stein, S. J. . Journal of Double Star Observations, 2(4), 134–137. http://www.jdso.org/volume2/number4/Daley3.pdf.

Farmer, L. D. (n.d.). McDonald Observatory Research Facilities. McDonald observatory. https://mcdonald.utexas.edu/for-researchers/research-facilities.

Gaia Collaboration et al. (2020a): Gaia EDR3: Summary of the contents and survey properties.

Gaia Collaboration et al. (2016b): The Gaia mission (describes the Gaia mission including spacecraft, instruments, survey and measurement principles, and operations).

Gibson, C. A. (2021, July 22). *0.4m LCO Aqawan Telescope.*

Harshaw, R. (2021, July 21). *Discovery Information of WDS 18494+5811.*

Harshaw, R. (2018). Gaia DR2 and the Washington Double Star Catalog: A Tale of Two Databases. Journal of Double Star Observations, 14(4), 734–740. http://www.jdso.org/volume14/number4/Harshaw_734_740.pdf.

Harshaw, R. (2020). Using Plot Tool 3.19 to Generate Graphical Representations of the Historical Measurement Data. Journal of Double Star Observations, 16(4), 386–400. http://www.jdso.org/volume16/number4/Harshaw_386_400.pdf.

Mason, B. (2021, July 19). WDS Historical Data Request.

Sordiglioni, G. (2020, December 25). WDS 18494+5811 STI2392. Stelle Doppie. https://www.stelledoppie.it/index2.php?iddoppia=77260.

0.4-meter. 0.4-meter | Las Cumbres Observatory. (n.d.). https://lco.global/observatory/telescopes/04m/.