Measuring the Position Angle and Separation of WDS 11194-0139

Madison Danalis, Freya Murcott-Green, Kiara Packard
Brisbane Girls Grammar School, Brisbane, Queensland

Abstract

Astrometric measurements of the position angle and separation of the double star WDS 11194-0139 were made using images taken on 15 May 2021 (2021.3149) with a 365mm Planewave reflecting telescope located at the Marrapatta Memorial Outdoor Education Centre, near Imbil, Queensland, Australia. Analysis of these observations yielded an average separation of 0.1566 arcseconds and an average position angle of 254.78 degrees.

1. Introduction

WDS 11194-0139 has been observed 91 times – observed first in 1796 and last in 2017, and now observed again in 2021 to continue the study of the recognition of a possible orbit (*WDS 11194-0139 STF1529,* n.d.). The data collected by Gaia on this binary system indicate it is a physical system due to the similarity between its proper motion and parallax, as shown in Table 1, however no orbit has been calculated. The primary star is a class F6IV and the secondary star is a class dG3 and the system is located in the constellation Leo. WDS 11194-0139 was selected for study as the system had many observations over the past 221 years, indicating that additional research could aid in the detection of a possible orbit. The parameters of the binary system was within the limitations of the telescope used (Δ magnitude = 0.81, ρ = 9.3", Declination = -1°) (*WDS 11194-0139 STF1529*, n.d.).

Table 1. Gaia proper motion and parallax data for WDS 11194-0139 (Brown, et al., 2018).

Proper Motion: Right Ascension A	Proper Motion: Declination A	Proper Motion: Right Ascension B	Proper Motion: Declination B	Parallax A	Parallax B
-221	-154	-220	-151	20.33	20.11

2. Equipment and Methods

The data for this project was gathered using the The Dorothy Hill Observatory (DHO), located at the Marrapatta Memorial Outdoor Education Centre, near Imbil, Queensland, Australia (The Dorothy Hill Observatory, n.d.). After a target was selected, twenty images were taken on 2021.3149 with an FLI CCD attached to a robotically controlled 356mm Planewave reflecting telescope with an Astrodon Gen 2 E-series luminance filter. The pixel scale of the camera was 0.72"/pixel in 1 x 1 binning mode with a 50' x 50' field of view. As the magnitudes of the primary and secondary star are 7.037 and 7.831 respectively, an exposure time of 10 seconds was found to provide suitable a signal-to-noise ratio (Hog et al., 2000). The raw images were calibrated for flat, dark, and bias using the Our Solar Siblings Pipeline (Fitzgerald, 2018) and these processed images were used in subsequent steps.

The position angle (θ) and separation (ρ) were measured in each image using the software AstroImageJ (Collins et al, 2017). The average position angle and average separation were calculated from the 20 images along with the standard deviation and error. In addition, the standard deviation and standard error of each mean were calculated.

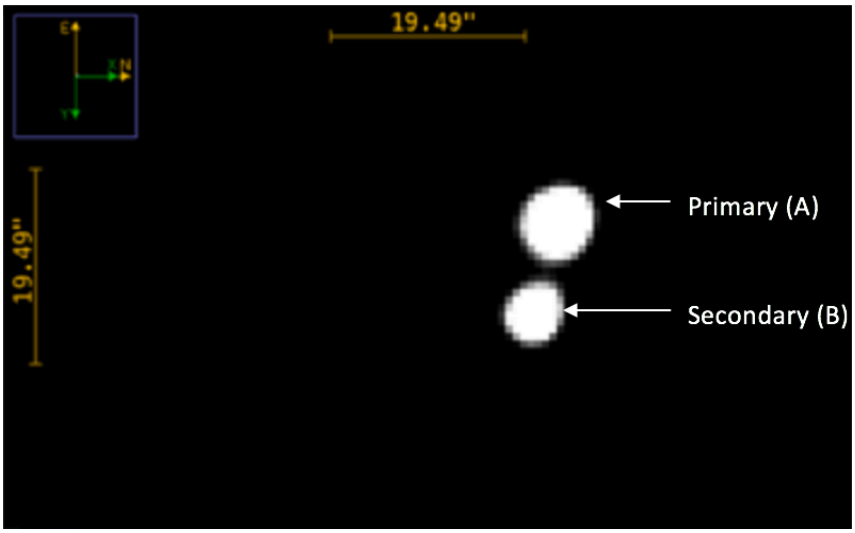

Figure 1: An observation of WDS 11194-0139 displayed in AstroImageJ

3. Data

The average separation across the 20 images of WDS 11194-0139 was 9.40 arcseconds and the average position angle was 254.78 degrees, as seen in Table 1.

Table 2. Measurements of the position angle and separation of WDS 11194-0139, STF 1529, from this study.

WDS 11194-0139 20x 10 Second 2021.3149		
Image	**Separation, ρ (")**	**Position Angle, θ (°)**
1	9.41	255.2
2	9.42	254.7
3	9.44	254.5
4	9.39	254.9
5	9.43	254.6
6	9.36	255.0
7	9.42	254.4
8	9.41	254.8
9	9.38	255.2
10	9.40	254.6
11	9.44	254.8
12	9.40	254.8
13	9.39	254.7
14	9.38	254.9
15	9.39	254.7
16	9.36	255.1
17	9.41	254.5
18	9.40	254.6
19	9.36	254.6
20	09.37	255.1

Table 3. Mean, standard deviation, and standard error of the mean for the WDS 11194-0139 position angle and separation measured in this study.

	Separation, ρ (")	**Position Angle, θ (°)**
Means	9.40	254.8
Standard Deviations	0.0004	0.24
Standard Error of the Means	9.3603×10^{-5}	0.05

In addition, historical data on this system was obtained from Dr. Brian Mason at the United States Naval Observatory. Using Plot Tool (Harshaw, 2020, p.3940), the historical data was plotted alongside the current observation, as seen in Figure 2. Observations that were more than 1.5 times the standard deviation were deemed outliers and removed. As seen in Figure 3, the removal of these outliers still failed to yield any evidence of a recognisable orbit.

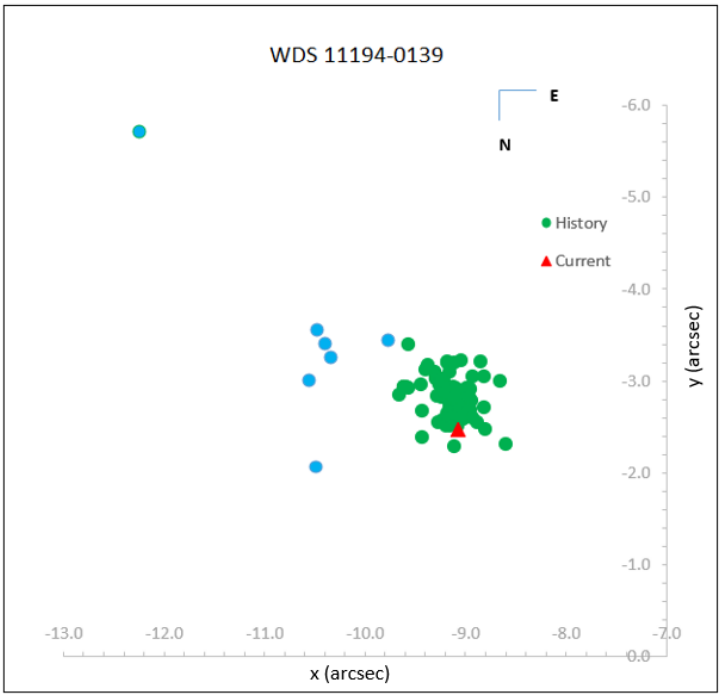

Figure 2: A plot of historical position angles and separations (green circles), alongside the position angle and separation measured in this study (red triangle). The blue circles represent outliers. The primary star is located at the origin in the bottom-right corner

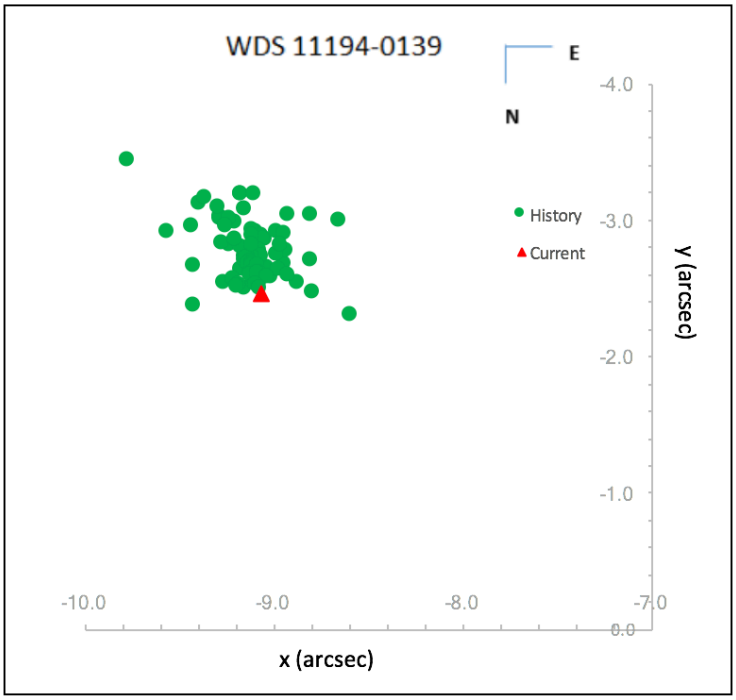

Figure 3: Historical position angles and separations (green circles), alongside the position angle and separation measured in this study (red triangle) with outliers removed. The primary star is located at the origin in the bottom-right corner

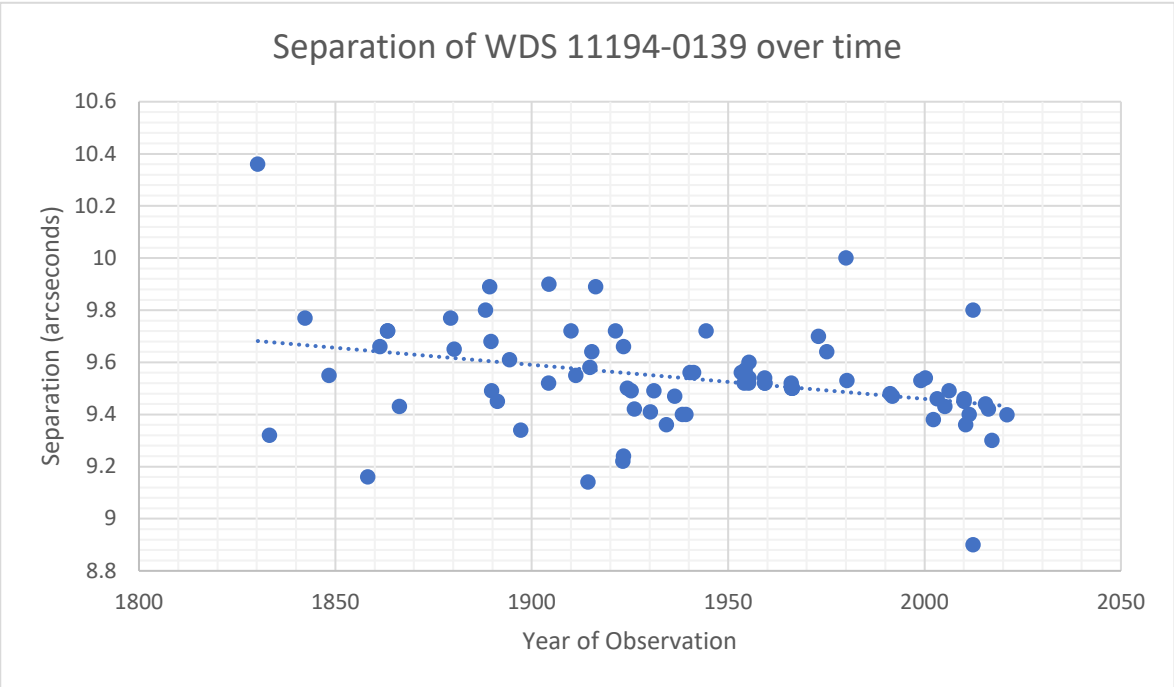

Figure 4: Year of observation versus separation of historical data and current observation, with linear trendline

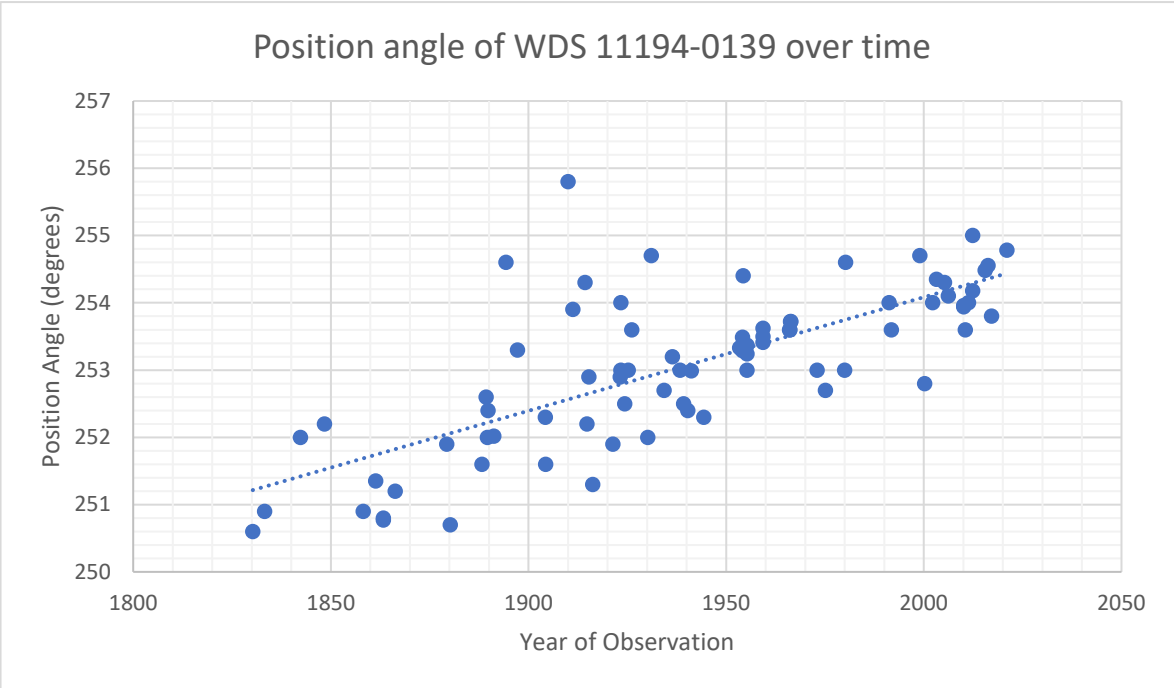

Figure 5: Year of observation versus position angle of historical data and current observation, with a linear trendline

As can be seen in Figure 4, the separation of the primary and secondary stars in WDS 11194-0139 has been minimal between 1830 and 2021. In addition, Figure 5 reveals a slight increase in the position angle for this system over the same period of time. To determine whether these changes in parameters could be attributed to the proper motion of the stars, Gaia data for proper motion was referenced.

Using the Gaia proper motion data displayed in Table 1, the expected separation and position angle were calculated to be 0.71 arcseconds and 18.43°, respectively. However, as is evident in Figure 4, the separation changed by only 0.29 arcseconds. Moreover, Figure 5 reveals that the position angle increased by 0.169° per year, so an average change of only 3.79° was observed.

4. Discussion

Initial examination of the plot of historical positions revealed a relatively stationary position of the secondary star due to the cluster of historical points near the centre of the graph in Figure 3. As changes in separation and position angle are considerably less than those calculated using the Gaia proper motion data, it is possible that the proper motion data for this system is flawed. As discussed by Harshaw (2017), such discrepancies between observations and proper motion projections are not uncommon. Additional observations of the proper motion of WDS 11194-0139 are required to explain the variation. As these changes in separation and position angle are minor, they are likely due to proper motion rather than orbital motion. Therefore, it can be concluded that WDS 11194-0139 is a physical but not an orbiting binary.

5. Conclusions

The position and separation of WDS 11194-0139 were measured using images taken from a 365mm Planewave reflecting telescope located at the Dorothy Hill Observatory in Imbil, Australia. When measured, the 2021 data revealed a position angle of 254.78 degrees and a separation of 9.40

arcseconds. When combined with historical data, these new measurements do not suggest that these stars are binary, rather that this double is only physical.

Funding

Observations in this paper made use of telescopes at the Dorothy Hill Observatory (DHO) in Queensland, Australia. The DHO is a facility established and funded by Brisbane Girls Grammar School.

Acknowledgements

The authors would like to acknowledge Dave Rowe for his Gaia double star selection tool, Dr Brian Mason of the United States Naval Observatory for providing historical data and Richard Harshaw for his Plot tool, used to plot the historical data. We would also like to thank Gerri Bernard and Anthony Lumsden for their guidance and support throughout this project. This work has used 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). This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France. This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory.

References

Brown, A. G. A., Vallenari, A., Prusti, T. J. D. B. J. H., De Bruijne, J. H. J., Babusiaux, C., Bailer-Jones, C. A. L., ... & Bertone, S. (2018). Gaia data release 2-summary of the contents and survey properties. *Astronomy & astrophysics, 616*, A1. https://doi.org/10.48550/arXiv.1804.09365

Collins et al. (2017, January). *AstroImageJ: Image processing and photometric extraction for ultra-precise astronomical light curves (expanded edition)*. Retrieved from https://doi.org/10.48550/arXiv.1701.04817

Fitzgerald, M. T. (2018). The Our Solar Siblings Pipe-line: Tackling the data issues of the scaling problem for robotic telescope based astronomy education projects. *Robotic Telescopes, Student Research, and Education Proceedings*, pp 347-358.

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/

Harshaw, R. (2017). When things don't look right: what appear to be proper motion discrepancies in the WDS. *Journal of Double Star Observations, 13*(4), 570-579. http://www.jdso.org/volume13/number4/Harshaw_570_5 79.pdf

The Dorothy Hill Observatory. (n.d.). Retrieved from https://www.bggs.qld.edu.au/about-brisbane-girls-grammar/facilities/dorothy-hill-observatory/

WDS 11194-0139 STF1529. (n.d.). Stelle Doppie. https://www.stelledoppie.it