Astrometric Measurement of WDS 12459-7511 HJ 4545

Isabel Zheng[1], Yael Brynjegard-Bialik[1], Jackie Roche[1], Pat Boyce[2], and Grady Boyce[2]

1 West Ranch High School, Stevenson Ranch, California, USA
2 Boyce Research Initiatives and Education Foundation, San Diego, California, USA

Abstract: This paper reports the astrometric measurements of the double star system WDS 12459-7511 HJ4545 using the Las Cumbres Observatory. We found the relative position of the AB pair to have a separation of 9.15" and position angle of 192.6° for epoch 2019.294. Additionally, the relative position of the AC pair was also measured to have a separation of 36.9" and position angle of 238.0° at for epoch 2019.294. When combined with GAIA parallax and proper motion data, the results strongly suggest that the AB pair is gravitationally bound and the AC pair is optical.

Introduction

The binary star HJ 4545 was selected because it met the following requirements:

- Observable from the Southern Hemisphere in the spring
- Angular separation of at least 5 arcseconds
- Difference in magnitude of no more than 3

HJ 4545, Figure 1, was first observed by John Herschel in 1835. Since the initial measurement, HJ 4545AB has been observed 22 times with the latest measurement in 2000 (Sordiglioni, G.).

The primary star has a spectral type of A5V (Mason and Hartkopf, 2015), and is a main sequence star. According to data from Tycho in the visible band, the A star has a magnitude of 9.1, the B star has a magnitude of 9.25, and the C star has a magnitude of 11.17. The initial and most recent measurements for each pair are outlined in Table 1. These measurements do not include those reported in this paper.

Materials and Methods

The images of HJ 4545 were taken in Sutherland, South Africa by an SBIG 6303 camera on a 0.4-meter Meade telescope, part of the Los Cumbres Observatory (LCO) system. A total of 7 images were measured and

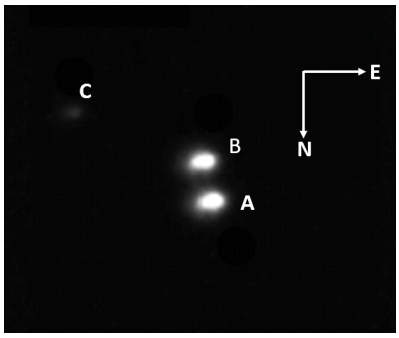

Figure 1. Image of WDS 12459-7511 cropped to show target stars.

Pair	Epoch	Theta	Rho
AB	1835 (Initial)	189.0°	12.000"
	2000 (Most recent)	192.0°	9.100"
AC	1895 (Initial)	235.9°	36.262"
	2000 (Most recent)	237.9°	36.930"

Table 1. Initial and most recent measurements of each star pair, excluding the measurements in this paper.

Astrometric Measurement of WDS 12459-7511 HJ 4545

Epoch 2019.294	Postion Angle (θ)	Separation (ρ)
Mean	192.6	9.15
Standard Deviation	0.264	0.023
Standard Deviation of the Mean	0.1	0.009

Table 2. Results of Mira Pro astrometric measurements of WDS 12459-7511 for AB.

Epoch 2019.294	Postion Angle (θ)	Separation (ρ)
Mean	236.5	36.3
Standard Deviation	1.081	1.111
Standard Deviation of the Mean	0.120	0.123

Table 3. Results of Mira Pro astrometric measurements of WDS 12459-7511 for AC.

taken on 2019.294 with an exposure time of 15 seconds using a Bessell B filter.

The images were calibrated by Our Solar Siblings (OSS) data pipeline (Fitzgerald 2018). The software, MiraPro x64, was used to measure the position angle (θ) and separation (ρ). These separation and position angle measurements were then entered into Google Sheets for calculations of the mean, standard deviation, and standard deviation of the mean for θ and ρ.

Results

A total of seven images were measured for the separation and position angle as shown in Table 2 and Table 3 for AB and AC, respectively.

Discussion

Astrometry, derived from these current results, are plotted together with historical data from the WDS, Figure 2. There is no apparent trend in the positions of the B or C star in relation to A over the period from first observation to our 2019 observation. The only points outside the tight patterns for both are the first two for B and could well be measurement error.

We found that Stelle Doppie (Stelle Doppie Web) has classified the AC pair as physical and the AB pair as uncertain. In Richard Harshaw's analysis of the WDS data merged with the Gaia DR2 data, he classified the AC pair as "unknown" largely because the Gaia DR2 data was missing from his merged database. He classified the AB pair as very likely to be physical. These opposing classifications arise from the differences in proper motions for the stars between the WDS and Gaia DR2, Table 3. The proper motions in RA for all three components are comparable between WDS and the more accurate Gaia DR2 data. The proper motions in DEC for the A and B stars are substantially different in the WDS but almost identical in Gaia DR2. Thus, Stelle Doppie's reliance on the WDS proper motions could have led to the conclusion that AC is physical and AB is not. Conversely, when the more accurate Gaia DR2 is applied, as in Harshaw, the nearly identical proper motions for the A and B stars yield a compelling case for their being physical and possibly weaken the case for AC to be physical. Figure 3 depicts the proper

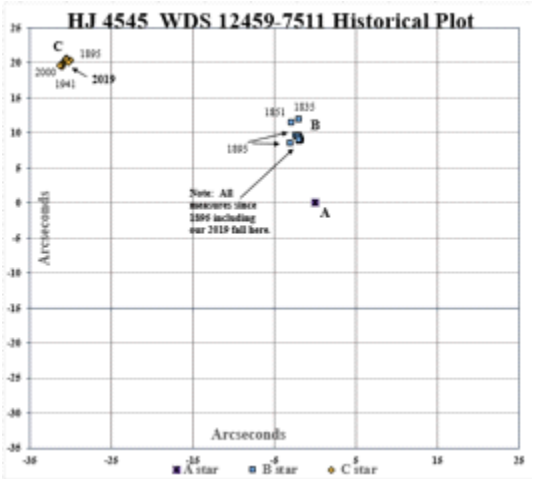

Figure 2. Historical positions of HJ4545 B and C compared to A at the origin.

Star	Proper Motion Data	RA	DEC
A	WDS	-028	+007
	Gaia DR2	-28.239	2.368
B	WDS	-030	-006
	Gaia DR2	-28.231	2.26
C	WDS	-038	+007
	Gaia DR2	-38.924	7.32

Table 3. Comparison of WDS and Gaia DR2 data for HJ 4545

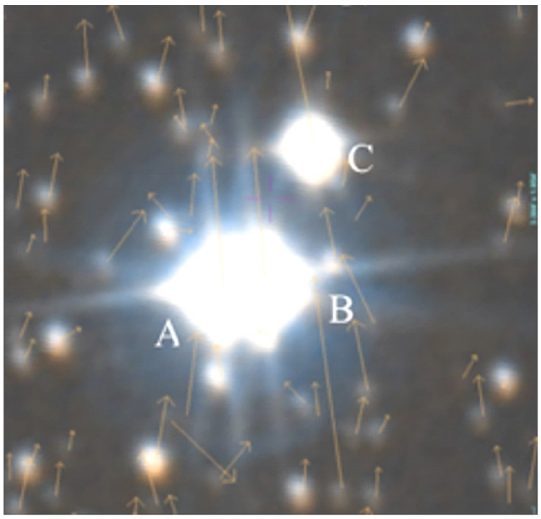

Figure 3. Image from Aladin 10 showing proper motion vectors for HJ4545

motion vectors of the system using ALADIN with GAIA data displayed.

Gaia DR2 parallax of the A star yields a distance of 789.29 light years and that of the B star yields a distance of 785.07 light years. Thus, with nearly identical proper motions and distances, this suggests the possibility that these two stars may be gravitationally bound.

The C star of the system has a parallax measure from Gaia DR2 that yields a much greater distance than the A and B at 1106.59 light years. The C star is likely to be optical as its proper motion vectors are different and its distance is distinct from the A star and B star. The parallax for the A star is 1.2669 x 10^{-3} arcseconds and the parallax for the B star is 1.2738 x 10^{-3} arcseconds while the parallax for C is drastically different at 9.0368 x 10^{-4} arcseconds.

Conclusion

After using the 0.4m telescope at LCO's South African observatory, we were able to provide additional astrometric data of the double star system WDS 12459-7511 HJ 4545. By applying data from Gaia DR2, we able to strongly suggest that s the AB pair is likely to be gravitationally bound and noted as a T in the WDS. The AC pair appears to be an optical double only and noted as an S in the WDS classification system.

Acknowledgments

The authors thank the United States Naval Observatory for providing historical measurement data and LCO for the use of their service, and we appreciate the ability to have Simbad and Gaia access from the CDS Strasbourg Database. We also thank Boyce Research Initiatives and Education Foundation (B.R.I.E.F.). Additionally, we thank Jerry Hilburn for his guidance and effort to the research team. Appreciation is extended to Christine Hirst for providing us the opportunity to participate in this project and supporting our team. Measurements were made using Mira Prox64, which provided accurate astrometric measurements for our double star system.

References

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*

Mason, B. and Hartkopf, W. The Washington Double Star Catalog, October 2015. Astrometry Department, U.S. Naval Observatory. https://ad.usno.navy.mil/wds/Webtextfiles/wdsnewframe3.html

O'Connor, J J, and E F Robertson. "John Frederick William Herschel." John Herschel (1792-1871), July 1999, www-history.mcs.st-andrews.ac.uk/Biographies/Herschel.html.

Stelle Doppie Web: Sordiglioni, Gianluca Stella Doppie, Double Star Catalog. https://www.stelledoppie.it/index2.php?iddoppia=54877 (Accessed Sept 15, 2019)