Astrometric Measurements of Double Star WDS 06047-4505

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Abstract: Measurements of the position angle and separation of the double star system WDS 06047-4505 were made on images taken by telescopes from the Las Cumbres Observatory (LCO) equipped with CCD cameras. The position angle was measured to be 5.77″ and the separation to be 213.52°. Analysis of the data when compared to previous measurements as well as parallax and proper motion data from Gaia strongly suggests this is a binary star. More observations are required in order to confirm the true nature of the double star.

Introduction

The research objective was to take astrometric measurements to determine the position angle (θ) and separation (ρ) of the AB component of the quintuple system WDS 06047-4505 in order to contribute to the astronomical knowledge base of this system. The Washington Double Star Catalog (WDS) and the Stelle Doppie website were used to determine candidate star systems. Telescopic capabilities (discussed below) and optimal viewing based on the time of year were factors considered in deciding upon criteria of a separation of 5-15 arc seconds and a magnitude between 6-11 for each star. Physical and uncertain doubles observed no later than 2015 that met those criteria were considered and WDS 06047-4505 HJ 3834AB was selected.

The quintuple star system WDS 06047-4505 was originally discovered by John Herschel in 1837 (Sordiglioni, 2015). According to Stelle Doppie, WDS 06047-4505 HJ 3834AB is an “uncertain” double (Sordiglioni, 2015). It has had 42 observations between 1837 and 2015. It was first measured with a position angle of 246° and a separation of 1.1″ in 1837. Its most recent measurement was a position angle of 215° and a separation of 6.0″ in 2015. The magnitudes of the primary and secondary stars are 6.02 and 8.98, respectively resulting in a delta magnitude (ΔM) of 2.96.

Methods and Observations

Looking at the calculated orbit of WDS 06047-4505, the most recent observation deviated from the calculated orbit, making this a system of interest. The observation portal was utilized to request images and then twenty images at just under one second exposure time were taken on October 2nd, 4th and 11th, 2020 with the SBIG STL-6303 camera at the Siding Spring, Australia, LCO telescope site. Historical data was obtained from Dr. Brian Mason at the U.S. Naval Observatory as well as from Stelle Doppie.

Results

Figure 1 shows an observation of WDS 06047-4505 HJ 3834AB taken from the Siding Spring LCO observatory being measured with the AstroImageJ software. The primary star is the object in the center and the secondary star is slightly bottom left of the primary.

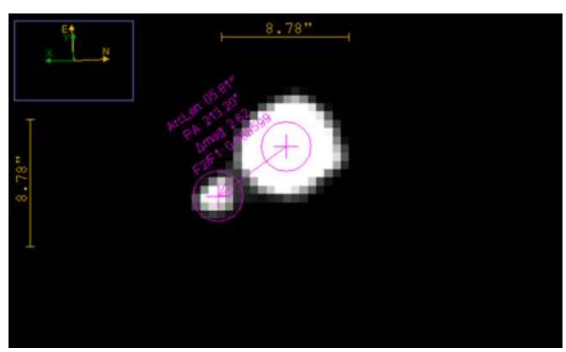

Figure 1: Figure 1: An image of WDS 06047-4505 taken with the Las Cumbres Observatory 0.4-meter telescope at Siding Spring Observatory

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Table 1 details the mean, standard deviation, and standard error of the mean (SEM) for the separation (ρ), 5.77″±0.02″ and position angle (θ), 213.52°±0.19° measured for HJ 3834AB.

Figure 2 shows the historical data and current measurement plotted on Cartesian coordinates, using Richard Harshaw's Plot Tool (Harshaw, 2020). The original data point from John Herschel was omitted as it was clearly an outlier. The graph indicates this is a short arc binary system, with an R2 value of 0.9051.

Obs #	Separation (arcsec)	Position Angle (deg)	Exposure Time (sec)	BJD
1	5.82	213.19	0.79	2459125.13
2	5.76	213.52	0.79	2459125.13
3	5.67	211.67	0.79	2459125.13
4	5.79	213.26	0.68	2459127.12
5	5.76	214.89	0.69	2459127.12
6	5.62	215.61	0.69	2459127.12
7	5.68	214.88	0.69	2459127.12
8	5.70	213.53	0.69	2459127.12
9	5.83	213.38	0.69	2459127.12
10	5.72	213.63	0.69	2459127.12
11	5.76	213.54	0.69	2459127.12
12	5.65	213.03	0.68	2459134.11
13	5.97	213.13	0.68	2459134.10
14	5.85	213.52	0.69	2459134.10
15	5.74	213.14	0.68	2459134.10
16	5.76	213.80	0.69	2459134.10
17	5.94	212.76	0.68	2459134.10
18	5.81	213.20	0.69	2459134.10
19	5.88	213.79	0.69	2459134.10
20	5.76	212.93	0.68	2459134.10
Mean	5.77	213.52		
Stan. Dev.	0.09	0.84		
SEM	0.02	0.19		

Table 1: Separation and position angle measurements for WDS 06047-4505 HJ 3834AB.

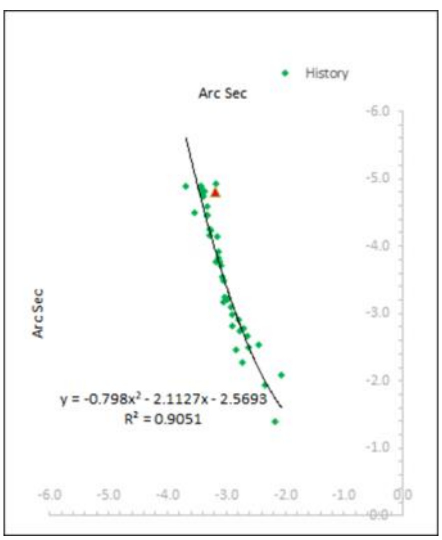

Figure 2: Plot of historical data and current observation, marked with a red triangle.

	Primary	Secondary
Parallax (mas)	36.5892	37.2282
Parallax Error (mas)	0.2665	0.0607
pmra (mas/yr)	-80.313	-83.454
pmdec (mas/yr)	254.158	236.476
magnitude	6.02	8.98

Table 2: Gaia Data

The current data point lies slightly off the calculated orbit as shown by the red triangle in Figure 3 below.

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However, it aligns closely with the several most recent speckle interferometry observations. Because speckle observations are generally highly reliable, it may be that a new orbit needs to be calculated based on the past few years of observations.

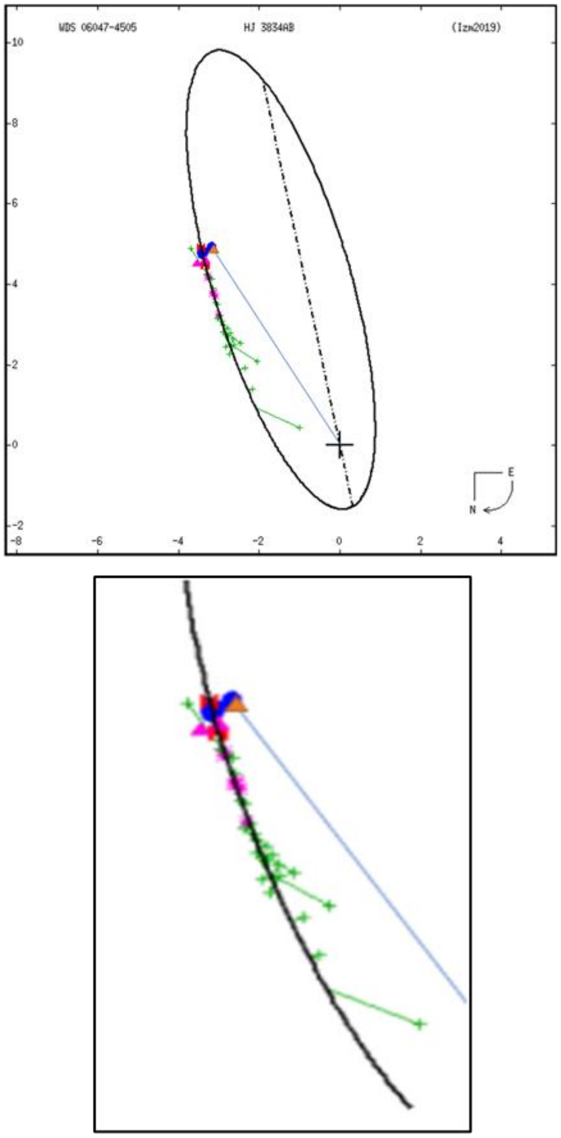

Figure 3: Orbital Diagram of WDS 06047-4505 with the current observation added and marked with a red triangle. The current observation aligns with recent speckle inferometry measurements.

Discussion

In an effort to distinguish WDS 06047-4505 as either a binary system or an optical double, the historical data was plotted. The cartesian plot of the historical data for WDS 06047-4505 shows the beginning of an arc, indicating this may be a true binary system. One of the challenges analyzing the WDS 06047-4505 system was the large delta magnitude and their close proximity.

Selecting an appropriate aperture was difficult because the star images were so different in size. The quality and resolution of the separation resulted in the need for additional images with shorter exposure times. Comparing the two stars, the primary has a parallax of 36.6 milliarcseconds (mas) with a mean error of 36.3 mas to 36.9 mas while the secondary has 37.2 mas with an error of 37.2 mas to 37.3 mas. Using the weighted parallax method (Harshaw, 2018), it is calculated that the two stars have a weighted minimum separation of 157 AU. The estimation of the physical distance shows a high possibility of the stars being gravitationally bound because "very few known binaries have separations that exceed 3,000 AU, and most are closer than 1,000 AU" (Harshaw, 2018). The calculated value of 157 AU is well within this separation range. Furthermore, the proper motion data from Gaia indicates that the stars are moving at similar rates, in similar directions. Referring to Table 2, the right ascension proper motion (pmra) of the primary star is -80.3 mas/year (yr) and the secondary star is -83.5 mas/yr. They are very large and also very similar in value. The declination proper motion (pmdec) of the primary star is 254 mas/yr while the secondary star has a pmdec of 236 mas/yr. Similarly, the values do not overlap, but they are very close. According to Harshaw (2018), "Two stars that are in orbit around one another should have identical, or very nearly identical, proper motions". Taken together, the changes in position angle and separation, along with parallax and proper motion data all suggest that this is a gravitationally bound system.

Conclusion

The latest observation of the star WDS 06047-4505 HJ 3834AB yielded a position angle of 5.77″ and a separation of 213.52°. A plot of the current observation alongside the historical data on a cartesian graph indicates a short-arc binary with an R2 value of 0.9051. Three distinct pieces of evidence contribute to the conclusion: the historical evidence, the current measurements, and the data available from Gaia regarding parallax and proper motion. Considering these three pieces of evidence, this star system appears to be a binary star system. This is a promising candidate worthy of further study to confirm that it is in fact a binary system.

Acknowledgments

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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. It also has made use of the SIMBAD database, operated at CDS, Strasbourg, France.

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