NEW MEASUREMENTS FOR WDS 11329-4342 HJ 4448AB

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Abstract

WDS 11329-4342 HJ 4448AB (HJ 4448AB) is a double star system in the constellation Centaurus. It was discovered in 1836 and has been observed 11 times, the most recent being in 2015. The physical nature of HJ 4448AB is "uncertain" according to the Washington Double Star Catalog (WDS). The 2015 observation returned a position angle (PA) of 88.286° and a separation (Sep) of 7.484". New measurements obtained for this report produced a PA of 88.5° and a Sep of 7.45". A plot of these new measurements combined with historical data did not give any indication that these two stars were physically bound. However, since the nature of this double star system will most likely remain "uncertain" following this report, further study is recommended.

1. Introduction

WDS 11329-4342 HJ 4448AB (HJ 4448AB) is a double star system in the constellation Centaurus located at right ascension (RA) $11^h\ 32^m\ 52.84^s$ and declination (Dec) -43° 41' 43.3". *Figure 1* shows the location of HJ 4448AB in the night sky as would be viewed from San Luis Obispo, CA during the month of March. The physical nature of HJ 4448AB is described as "uncertain" in the Washington Double Star Catalog (WDS).

Figure 1: Location of HJ 4448AB in the constellation Centaurus

Double star systems, or binaries, are pairs of stars that appear very close together in the sky. Some can be seen with the unaided eye, but most require a telescope to resolve the individual stars. Double star systems can be physical binaries - gravitationally bound and orbiting a common center of mass, or visual binaries - not gravitationally bound and only appear close to each other. The larger or brighter star is called the primary star or A component, and the smaller or dimmer star is called the secondary star or B component. Some gravitationally-bound systems actually contain several stars but for this report we will concentrate on systems containing just two stars.

We used various sources of information for this report, such as the WDS which is the principal database of astrometric double and multiple star information maintained by the United States Naval Observatory (USNO), and the Gaia Data Release 3 (Gaia DR3) which provides precise astrometric measurements of celestial objects collected by the Gaia space telescope maintained by the European Space Agency (ESA).

1.1 Target Selection

Since a large part of our research was going to rely on high resolution images taken by ground-based telescopes we knew our target selection had to meet certain criteria. We used Stelle Doppie, a website that searches the WDS database using filters set by the user.

We used the following filters:

- **RA between 7 and 17 hours.** This would limit search results to systems that would be visible at night at the time of this study (March-April). This information was obtained using Stellarium, a free and open-source software that simulates a planetarium.
- **Dec:** It was not necessary to specify a Dec since telescopes are located in both the northern and southern hemispheres.
- **Last observation in 2015 or before.** This was to give positions time to change.
- **Magnitude of primary star between 7 and 12.** This makes it bright enough to be easily observed and photographed but not so bright that it dominates the sky.
- **Delta magnitude between primary and secondary stars less than 4.** This was so the brighter star would not obscure the dimmer star in the images.
- **Sep between between primary and secondary stars between 5 and 10 arcseconds.** This would allow the two stars to be easily resolved in the images while keeping them both in the same frame when zoomed in.
- **Number of past observations between 7 and 15.** This was so there would be sufficient historical data available but not so much that any new data would become redundant.
- **"Named stars" option checked.** Reasoning that it may be difficult to find complete records on unnamed stars.
- **"Uncertain double" option checked.** This filtered out any doubles that had already been confirmed as either physical or not physical.

These filters returned 109 double star systems from the WDS. We picked 6 systems on which to perform some preliminary research. This research included requesting high resolution photo images and comparing astrometric data from the WDS. After careful analysis we selected HJ 4448AB to be the subject of this report. We based this on what initially appeared to be a reasonable chance the two stars were physically bound due to their having similar parallax and proper motion values. Unfortunately, the WDS did not list the relative distance of the secondary star. However, when we later consulted the more comprehensive Gaia DR3 database we discovered that the two stars were at least 30 light years apart making it unlikely they were physically bound (see Table 1).

Table 1. Astrometric data of HJ 4448AB from the Gaia DR3 database.

System	Star	Source ID	Parallax *(mas)*	PMRA *(mas/yr)*	PMDEC *(mas/yr)*	Radial Vel *(km/s)*	Dist *(l.y.)*	rPM
WDS 11329-4342 (HJ 4448)	Primary	5381923295560864256	2.32	-14.00	-1.05	-5.43	1496.39	0.141
	Secondary	5381923295560864640	2.28	-14.91	0.86	-6.07	1466.28	

PMRA = Proper Motion Right Ascension
PMDEC = Proper Motion Declination
rPM = ratio of Proper Motions metric
mas = milliarcseconds

The ratio of Proper Motions metric (rPM), (Harshaw, 2016), measures how different the two proper motions are from each other relative to the size of the larger of their two vectors.

The equations for calculating rPM are as follows:

$$Resultant = \sqrt{\left(R_{pri} - R_{sec}\right)^2 + \left(D_{pri} - D_{sec}\right)^2}$$

$$Vector = \sqrt{R^2 + D^2}$$

$$rPM = \frac{Resultant}{Vector}$$

where:
R_{pri} and R_{sec} represent the RA of the primary and secondary stars respectively.
D_{pri} and D_{sec} represent the Dec of the primary and secondary stars respectively.
R^2 and D^2 represent the squares of the RA and Dec of either star, whichever has the larger vector.

2. Equipment and Methods

On 2024.2574, we submitted observation requests to the Las Cumbres Observatory (LCO) through the observation portal on their website. LCO is a network of telescopes with locations all over the globe which can be used by both amateur and professional astronomers for education and research (Gomez and Fitzgerald, 2017). We provided the coordinates and indicated the number of images, the exposure time, and the filter type. The LCO used their 0.4m telescope with a DeltaRho 350 + QHY600 camera located at the South African Astronomical Observatory (SAAO) in Southerland, South Africa. LCO provided us with high resolution images in a *flexible image transport system* (FITS) digital file format. The images were calibrated using the LCO's automatic BANZAI pipeline. See *Figure 2* for LCO locations.

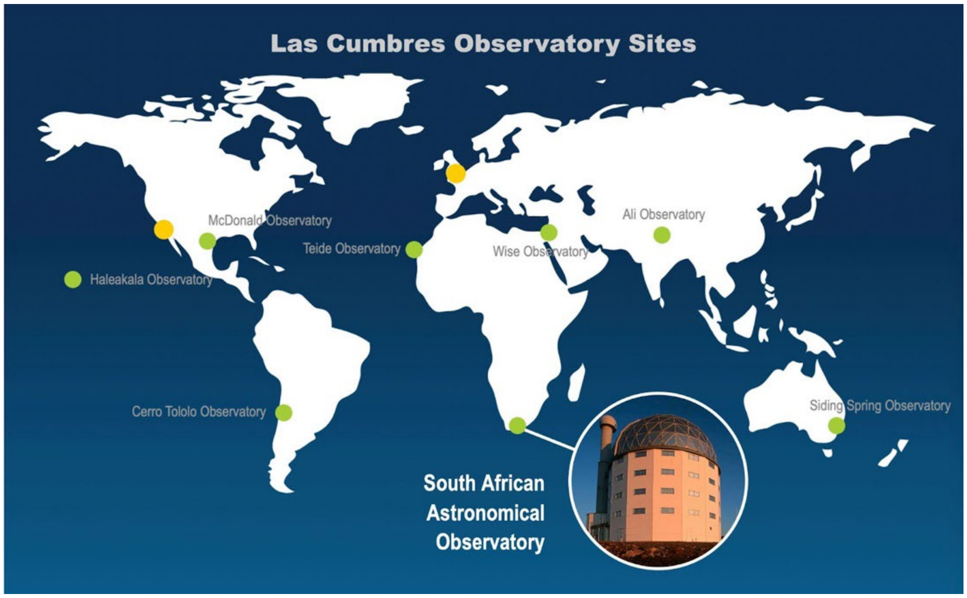

Figure 2: LCO sites with SAAO inset

To obtain PA and Sep measurements using these images we utilized Afterglow Access (AgA), a browser-based astronomy image and data analysis software tool. AgA allows the user to find the centroid of the star automatically using the position that represents the weighted average of the pixel brightness.

After zooming in and adjusting brightness and contrast levels to produce a clearly defined image of the two stars, the user then command-drags the cursor from the primary to the secondary star to obtain the PA and Sep values. See *Figure 3* for a sample image of HJ 4448AB.

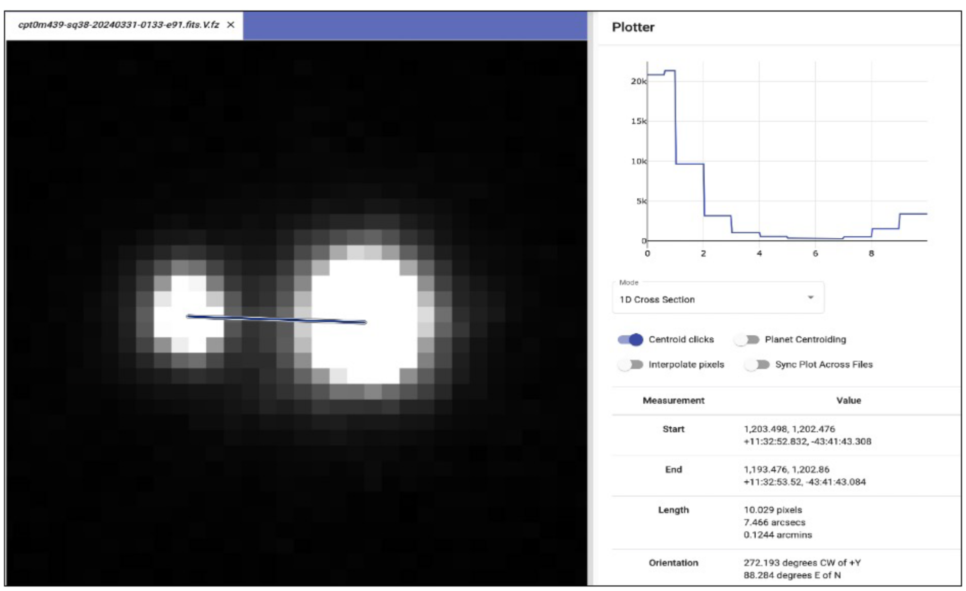

Figure 3: Sample image of HJ 4448AB double star system from AgA

3. Data

On 2024.2574 LCO captured 10 images of HJ 4448AB using a Bessell-V filter and an exposure time of 2 seconds per image. From these images we measured the PA and Sep using AgA software. Table 2 summarizes the measurements of all 10 images.

Table 2: New measurements for HJ 4448AB.

Image No.	Sep (")	PA(°)
1	7.47	88.3
2	7.42	88.0
3	7.48	87.8
4	7.47	87.9
5	7.46	88.3
6	7.49	89.4
7	7.46	88.6
8	7.42	88.8
9	7.45	89.6
10	7.46	88.6
Mean	7.46	88.5
SD	0.024	0.60
SEM	0.007	0.19

SD = Standard Deviation.
SEM = Standard Error of the Mean.

We then requested historical data for HJ 4448AB from Rachel Matson at the U.S. Naval Observatory (USNO). This is summarized in Table 3. We added our new measurements (mean values from Table 2) to the bottom of Table 3.

Table 3: Historical data for HJ 4448AB.

Date	Sep (ρ) *arc-sec* (")	PA (θ) *degrees* (°)
1836.20	6.0	91.1
1902.20	7.56	90.0
1902.21	7.314	89.2
1913.02	7.84	88.6
1948.41	7.39	89.0
1965.81	7.21	88.8
1991.25	7.486	88.2
1991.46	7.48	88.3
1999.058	7.524	88.9

Date	Sep (ρ) *arc-sec* (")	PA (θ) *degrees* (º)
1999.28	7.42	88.9
2015.0	7.484	88.286
2024.2574	7.46	88.5

4. Discussion

To visualize the apparent motion of the two stars as they would be seen in the plane of the sky, we converted the ρ, θ cylindrical coordinates from Table 3 into *E, N* (east, north) Cartesian coordinates using the following equations:

$$E = \rho \sin \theta$$
$$N = -\rho \cos \theta$$

where θ is expressed in radians.

Table 4: Historical data in Cartesian coordinates.

Date	E *arc-sec* (")	N *arc-sec* (")
1836.20	6.00	0.12
1902.20	7.56	0.00
1902.21	7.31	-0.10
1913.02	7.84	-0.19
1948.41	7.39	-0.13
1965.81	7.21	-0.15
1991.25	7.48	-0.24
1991.46	7.48	-0.22
1999.058	7.52	-0.14
1999.28	7.42	-0.14
2015.0	7.48	-0.22
2024.2574	7.46	-0.19

E and *N* are also referred to as RA and Dec respectively (not to be confused with the RA and Dec used to locate stars on the celestial sphere). We used a symbol convention to help differentiate between the time periods. The symbols and dates they represent are as follows: ■ (square) = 1836.20-1913.02, ▲ (triangle) = 1948.41-1991.46, ● (circle) = 1999.058-2015.0 and ★ (star) = 2024.2574.

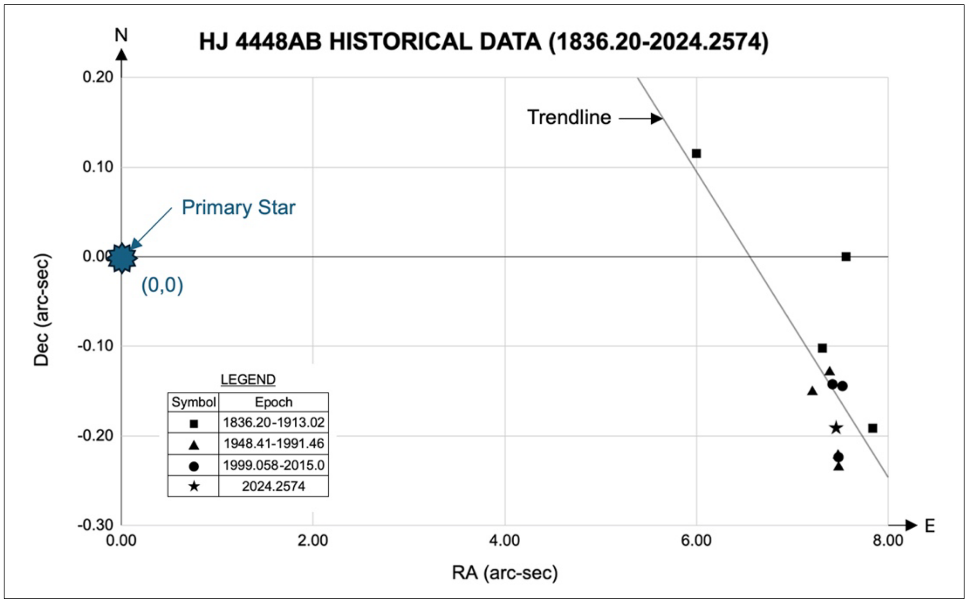

Figure 4: Plot of historical data using Cartesian coordinates

The plot reveals a non-uniform linear trend over time with no evidence of a curvature that might indicate an orbit. This non-uniformity could be attributable to atmospheric effects, noise in the data, or inconsistent measuring methodologies from one observation to the next.

The rPM value of the HJ 4448AB is 0.141. According to Harshaw, double star systems with an rPM value less than 0.2 exhibit common proper motion (CPM), suggesting they may be gravitationally bound. However, we established earlier in this report that the two stars are at least 30 light years apart, so the small rPM value here most likely means that these stars just behave similarly, possibly indicating that they formed at the same time in the same region of space.

5. Conclusions

The PA increased slightly (88.3° to 88.5°), and the Sep decreased slightly (7.48" to 7.46") since the last observation in 2015. If these trends were to continue, a curvature in the plot could start to develop indicating the existence of an orbit. Although Gaia DR3 data indicate the two stars are too far apart to be gravitationally bound, it is possible this data is inaccurate and future advancements in measuring technology could show that these two stars are closer than previously thought.

There is a reason why the nature of this double star system is described as "uncertain." We don't know what that reason is, but we assume it's because more observations are needed. For this reason, we recommend that the double star system HJ 4448AB continue to be monitored, for as long as its nature remains "uncertain."

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This work has also made use of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/web/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, particularly the institutions participating in the Gaia Multilateral Agreement.

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