Astrometric Measurement of WDS 13433-2458 AB

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Abstract: By utilizing Las Cumbres Observatory (LCO) telescopes equipped with CCD imaging, measurements of theta and rho of the double star system WDS 13433-2458 AB (HJ 2671) were made. When compared to the 18 previous measurements of the system, the data does not point to signs of orbital motion and suggest that WDS 13433-2458 AB may not be physical.

Introduction

By determining the true nature of double and multiple star systems—whether or not they are gravitationally bound—astronomers can determine the masses of the system (and of each star if the distance is known and a good orbit derived); and other stellar characteristics such as radius, density, and the mass-luminosity relationship (MLR), can be estimated. As part of the Boyce Research Initiatives and Education Foundation (BRIEF), this research project aims to assist in the verification of whether a system is a gravitationally associated double or an optical double.

WDS 13433-2458 AB (HJ 2671AB) was selected after meeting the following criteria: right ascension (RA) of 12 to 16 hours for reduced air mass during imaging, delta magnitude of 3 or less, and separation of 5 to 15 arcseconds for image clarity.

Materials and Methods

Historical data for HJ 2671 AB was provided by the United States Naval Observatory, from which we derived a historical chart of theta and rho over time, Figure 1. The first measurement of HJ 2671 was in 1831 and it has been measured a total of 18 times (with the most recent observation being in 2016). Several sources,-- the Washington Double Star Catalog (WDS), GAIA, and Aladin 10-- were consulted for stellar data such as radial velocity, proper motion vectors, and parallax data. Key data points from GAIA are shown in Table 1.

The Las Cumbres Observatory (LCO) 0.4m telescopes were used to observe HJ 2671AB. Requests for these images were processed through the LCO Observing Portal with exposure times calculated using the LCO Exposure Time Calculator. SBIG CCD cameras with 2048 X 3072 pixels had a resolution of 0.57" per pixel and a field of view of 19′ X 29′. An SDSS-g filter was used to photograph HJ 2671 on Julian Date 2458580 at for a total of 12 images at 3 seconds exposure time each. With this telescope setting we deter-

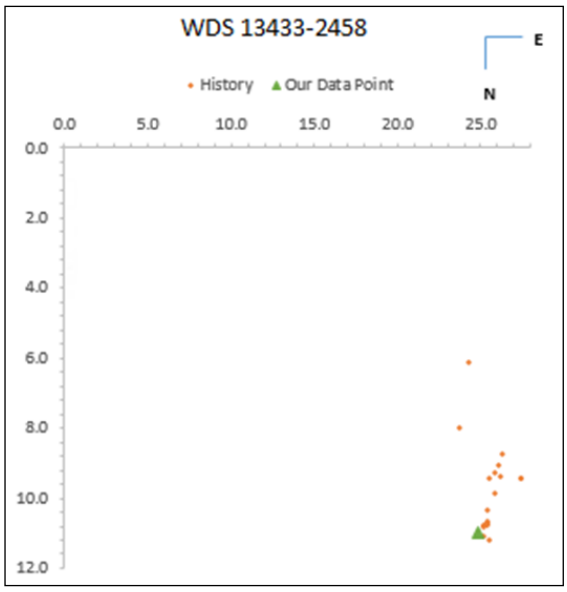

Figure 1. Historical Graph

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	Primary Star	Secondary Star
	HJ 2671 A	HJ 2671 B
Proper Motion RA	-33.407	-38.895
Proper Motion RA Error	0.109	0.089
Proper Motion Dec	-14.294	0.8
Proper Motion Dec Error	0.108	0.081
Parallax	7.9587	1.8924
Parallax Error	0.0588	0.047
Radial Velocity	-13.12	-79.31
Radial Velocity Error	0.69	0.35

Table 1. Table of Gaia data

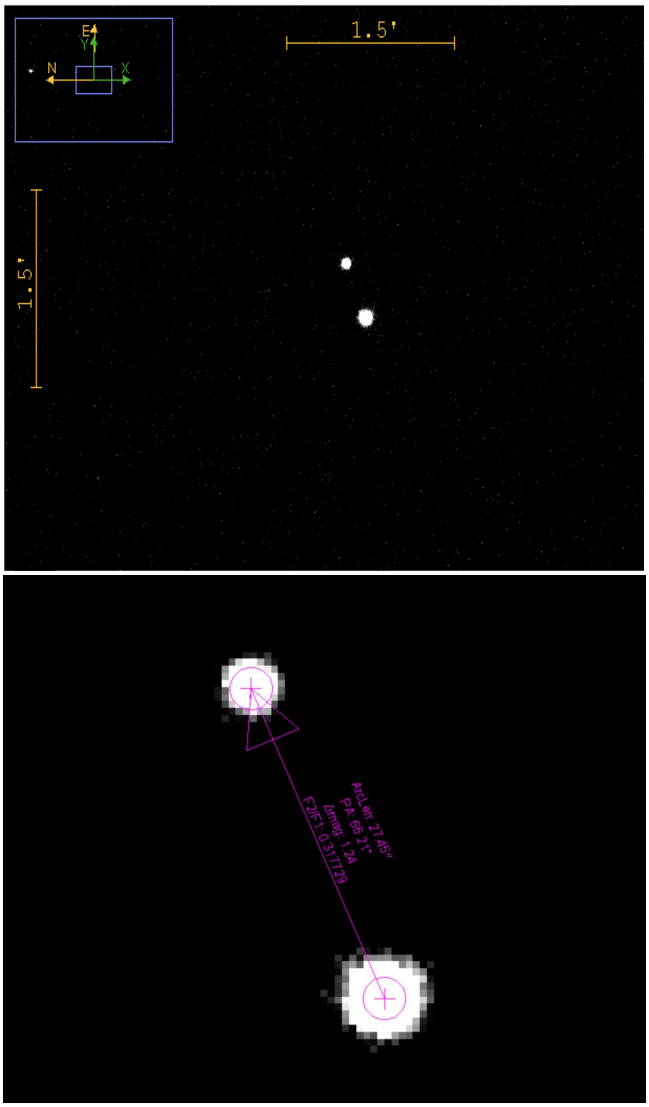

Figure 2. Images of HJ 2671 AB being measured in AstroimageJ

mined that on 2458580, HJ 2671 AB had a theta value of 66.099 degrees and a rho value of 27.507 arcseconds.

Each image was processed through the Our Solar Siblings (OSS) Pipeline to remove image imperfections and insert World Coordinate System (WCS) coordinates into the image files (Fitzgerald 2018). AstroImageJ (AIJ) was used to provide measurements of theta and rho, Figure 2, in order to compare them to the measurements found in the historical data. Once measured, the mean and standard deviations of the measurements were calculated, Table 2.

Results

Table 1 outlines the data obtained from the GAIA database. Table 2 shows the Mean, Standard Deviation, and Standard Error of the Mean for the position angle (θ) and separation (ρ) measured for HJ 2671AB.

Discussion

A graph of the historical data of the star, Figure 1, shows a roughly linear pattern in the movement of the B star relative to A. The trend indicates that the B star is moving in a northwesterly direction with a proper motion value of <-38.895, 0.800>. However, considering the individual motions of A and B against the celestial sphere, the A star is not moving in the same direction as the B star, but instead is moving in a southwesterly direction with a proper motion value of <-33.407, -14.294>, illustrated in Figure 3 where the proper motion vectors of the A and B star have been superimposed onto the image in Aladin10. Additionally, data from the GAIA satellite indicate the radial velocities of

Epoch 2019.264	Mean	Standard Deviation	Standard Error of Mean
Theta (degrees)	66.099°	0.065°	0.021°
Rho (seconds)	27.505"	0.028"	0.009"

Table 2: The mean, standard deviation, and standard error of the mean of the data collected

the A and B star respectively are -13.12 and -79.31. Since both of these values are negative, the two stars are moving away from Earth but because there is a 66.19 difference in radial velocities, we do not believe that they are moving away from Earth together.

Analysis of this data suggests that the stars are not

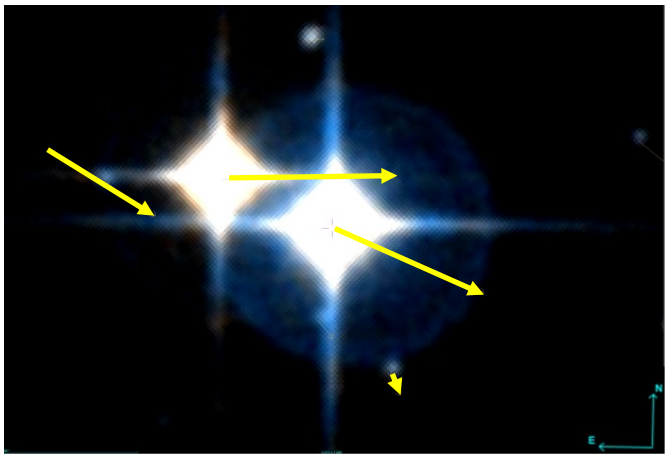

Figure 3: An image of HJ 2671 AB with proper motion vectors

moving together and instead are pursuing different paths through space. This is further supported by parallax data acquired from the GAIA satellite. The A star has a parallax of 7.9587 and an error of 0.0588, which puts the A star at a distance of 406.61 to 412.66 light years away from Earth. The B star's parallax is 1.8924 with a parallax error of 0.0471, placing the B star at a distance of 1681.19 to 1767.03 light years away, making the two stars separated by at least 1268.53 light years. The distance by which these two stars are separated is considerable and considering the inverse square relationship between the force of gravity and distance, we do not believe that HJ 2671 A is gravitationally bound to HJ 2671 B over a distance of 1268.53 light years.

Conclusion

The large distance between the A and B stars, the lack of a trend indicative of an orbit on the historical graph that included our current measurements, and the difference in proper motion vectors suggest that the star system is not a physical double.

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