CCD Astrometric Measurements and Historical Data Summary of WDS 06412-4021

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Abstract

We analyzed measurements of the star system, WDS 06412-4021 HJ5443 using the Las Cumbres Observatory network of telescopes. We calculated mean position angle (θ) and mean separation (ρ) values of 107.37º and 15.59”, respectively, and a magnitude difference of 3.26. The data we collected suggests that these two stars may be gravitationally bound, however uncertainty in certain measurements may suggest the binary status of these two stars is still inconclusive.

1. Introduction

The research detailed in this paper was made possible by Boyce Research Initiatives and Education Foundation (BRIEF). BRIEF allows amateur astronomers the opportunity to conduct astrometric research of double star systems. This paper details the authors’ efforts to help add to the understanding of the neglected star system WDS 06412-4021, an optical double or gravitational binary. The focus of this research is position angle (θ), separation (ρ), and astrometric measurements outlined by the Washington Double Star Catalog (WDS). Determining the type of double star in this system can provide insight for future research by astronomers.

We collected astrometric measurements of the double star system WDS 06412-4021 (hereafter referred to as HJ 5443). The criteria outlined for the selection of this system were that it must in the spring, have an angular separation greater than six arcseconds, and not have been observed in recent years. Following the determination of several candidates, the system HJ 5443 was chosen. Figure 1 and historical data was requested from the United States Naval Observatory (USNO) to do primary analysis. Located in the constellation Puppis, the system has a right ascension of $06^h\ 41^m\ 14.17^s$ and a declination of 40° 20' 59.5", placing it in the southern hemisphere. In addition, the primary star is of the spectral class B4V (blue white).

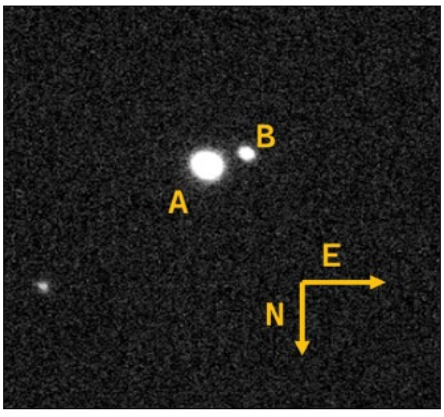

Figure 1. Raw CCD Images of WDS 06412-4021 (HJ 5443) with the Bessel V filter with an exposure of 1.5 Seconds

The first observation of HJ 5443 was by John Frederick William Herschel in 1835. Ten additional observations have been made, ranging until 1999. Values were requested from the Washington Double Star Catalog (WDS), part of the United States Naval Observatory (USNO). All observations excluding the first have similar values for position angle and separation, summarized in table 1.

WDS 06412-4021		
Epoch	**Theta (°)**	**Rho (“)**
1835.99	104.7	17.25
1897.2	107.6	15.06
1900.12	106.4	15.887
1904.13	107.2	16.9
1904.13	106.4	17.153
1920.18	107.3	15.58
1933.83	107.3	15.27
1991.25	107.8	15.448
1991.44	107.8	15.45
1999.009	109.3	15.613
1999.12	107.5	15.45

Table 1. Historical θ and ρ values from the USNO. Small changes are shown in the table, the range for θ is 4.60° and 2.19” for the value of ρ.

2. Equipment and Methods

Twenty-one images were taken from the Las Cumbres Observatory’s (LCO) telescope located in Siding Spring, Australia, which uses a Meade 16-inch RCS tube telescope with an SBIG STL6303 Camera, shown in Figure 2. This camera has a variety of filter options with a 29’ x 29’ field of view, and a camera pixel scale of 0.571” per pixel. These images used a variety of filters to attempt to resolve both stars as best as possible, due to their high delta magnitude.

Figure 2. Telescope used at the Sliding Springs Observatory.

Selected photos, designated by quality (those not grainy or overexposed), were plate solved using the Our Solar Siblings Pipeline (Fitzgerald 2018). After processing, these images were analyzed on the AstroImageJ Suite. In addition to these images, data from the European Space Agency’s Gaia 2 Data release and the USNO were used for further analysis. Final images used the Bessel V filter, and all runs are summarized in Table 2.

WDS	Tel	Date	Filter	Number
06412-4021	LCO	2021-05-03	Bessel V	12

Table 2. Observational Requested Values across Different Dates, with image request numbers.

3. Data

After running analyses on the observations obtained on epoch 2021.3364, with a total of eight images, the AstroImageJ program yielded the following results (Table 3):

Telescope, Images, Filters	Epoch 2021.3364	θ (°)	ρ (“)	Δ Mag
LCO, Bessel B.	Mean	108.03	15.49	2.76
	Std Dev	0.5188	0.1874	0.2351
	Std Err	0.2237	0.13	0.23

Table 3. Results table from observations.

4. Discussion

Using the small angle approximation based on the separation angle of 15.49” and the distance of 915 light years for HJ 5443 A and 905 light years for HJ 5443 based on Gaia Parallax data, Table 4, the stars could be as close as 0.07 light years in the plane orthogonal to our line of sight (Table 4). This separation hints that they are close enough to be gravitationally bound, although it is impossible to say whether they are directly on the visual plane or not, making this piece of evidence useful, but inconclusive.

Star Name	Light Years			Parsecs		
	-1 SEM	Midpoint	+1 SEM	-1 SEM	Midpoint	+1 SEM
HJ 5443 A	812.98	915.11	1046.59	249.38	280.71	321.04
HJ 5443 B	901.56	905.00	908.46	276.55	277.61	278.67

Table 4. Calculated distances with standard error.

The probability of the two stars being within one light year of each other in the radial direction was found to be 0.7% (Bob Buchheim personal contact). The error in measurement for the calculated values referenced from Table 3, show that Star A has an order of magnitude of more error than star B, making the AB separation in the radial distance to determine their nearness uncertain. However, upon the next release of Gaia, Gaia Data Release 3, this error may be reduced.

Star Name	Proper Motion α	PMRA Error	Proper Motion δ	PMDEC Error
HJ 5443 A	0.52	0.066	-4.9895	11.018
HJ 5443 B	0.16	0.2	-4.906	9.541

Table 5. Proper motion for component stars with error

5. Conclusions

Our analysis of the eight images used, in addition to the reference data from Gaia determine that the two stars cannot be ruled out as gravitationally attracted, most measurements and historical data support a gravitational relationship. Unfortunately, there is too much uncertainty in the parallax for the gravitational state of these stars to be determined with certainty.

6. Acknowledgements

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