Astrometric Measurements of Star System WDS 06571+5438

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Abstract: We report CCD astrometric measurements of the double star system WDS 06571+5438 (HJ 2350) obtained using Las Cumbres Observatory (LCO) sites and AstroImageJ (AIJ) software. We found a mean position angle of 195.76° ± 0.4° and a mean separation distance of 6.24" ± 0.04". Calculations found for distance between the stars using Gaia Parallax data suggest that the system is an optical double.

Introduction

The goal of this study was to select a double star system to research and observe using CCD imaging in order to determine whether the system is binary or not. A comparison of data listed by the Washington Double Star Catalog (WDS), the Stelle Doppie Double Star Database (Stelle Doppie), and Dave Rowe's WDSGaiaDR2 V2 (Harshaw 2018) excel spreadsheet lead to the selection of this star system. Candidate systems for our research were chosen based on the following specifications: being positioned between 00-08H of Right Ascension (RA) and a Declination (DEC) between +35 and +50 degrees to optimize imaging potential. Other qualifications required that the primary star (*a*) had a magnitude between 7 and 12 and a secondary star (*b*) a magnitude between 7 and 13; and a delta magnitude no larger than 3. Selecting systems with these magnitudes, as well as ones with a angular separation (ρ) of at least 5" to ensure both stars within the system were easily distinguishable.

The observed star system WDS 06571+5438 HJ 2350 (hereinafter HJ 2350) fit these qualifications. HJ 2350, discovered by John Herschel in 1831, is located in Lynx (Stelle 2018). The spectral class of *a* is F8 (Stelle 2018) and *b* is determined to be F9 using the GAIA Archival Data (GAIA 2018), which is graphed on the HR Diagram in Figure 1. The difference in magnitude (Δmag) between the stars is 2.03, with *a* having a magnitude of 9.47 and B with a magnitude of 11.50. There have been 13 observations since 1831; the most recent being in 2016. When first observed, its position angle (θ) was documented as 225° with a rho (ρ) of 10" (arcseconds) and the last observation, 2016, found it to have a θ of 197° with a ρ of 6.3" (WDS 2018).

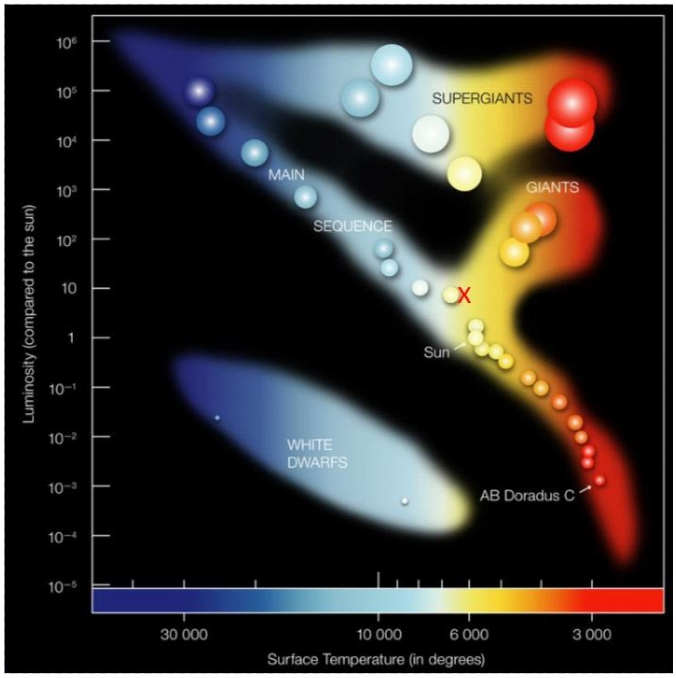

Figure 1. HR Diagram with graphed b star with effective temperature of 6185.5K and a solar luminosity of 9.591 L☉

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Equipment and Procedures

The system has an RA of 06h 15m 06.99s and DEC of +44° 09' 35.7" (Stelle 2018). Based on the DEC of the system, it was deemed most appropriate to utilize one of the northern hemisphere Las Cumbres Observatory (LCO) sites, which range in DEC approximately +20 to +30. Each site utilizes an LCO developed 0.4m telescope, Figure 2, equipped with an SBIG STX6303 CCD camera. The camera has a resolution of 0.57" arcseconds making it sufficient for resolving the approximate separation of 6.3". A total of 58 images were ordered: fifteen of these images utilized the Pan-STARRS W filter which comprises a wavelength center of 6250Å and wavelength width of 4416Å with an exposure time of 1 second. The remaining 43 images utilized the SDSS R' filter which comprises a wavelength center of 6215Å and a wavelength width of 1390Å with exposure times of 0.5 seconds, 1 second, and 1.5 seconds. The Our Solar Siblings (OSS) pipeline processed all images and exported them as FITS files (Fitzgerald 2018).

The program AstroImageJ (AIJ) was utilized to take measurements of the θ, ρ, and Δmag of the star system by first approximating the centroids of both components and fine-tuning based on the aperture selection (Collins 2018). These results for each image were exported as an excel spreadsheet that included the mean, standard deviation, and standard error calculations for comparison with the historical data received from WDS (Mason 2018).

Figure 2. 0.4 m diameter telescopes equipped with SBIG STX6303 camera and mounted at the Cassegrain Focus. These telescopes use CCD imaging with a total field of view of 19 x 29 arcminutes (LCO 2018)

Data & Measurements

Listed below are the historical data points as reported by the WDS (Table 1) in comparison with the data acquired in this observation (Table 2).

Table 1. Listed above are the historical observations provided by WDS

Observation Date (year)	Position Angle (θ)	Separation Distance (ρ)
1831.11	224.5°	10.0"
1903.08	213.9°	10.364"
1909.076	213.9°	9.92"
1913.10	217.5°	9.992"
1915.60	220.9°	10.0"
1918.11	224.0°	9.752 "
1988.17	206.0°	7.05"
1999.01	200.5°	6.88"
2003.21	200.1°	6.716"
2003.77	200.1°	6.677"
2011.62	198.01°	6.35"
2011.823	197.77°	6.42"
2015	196.817°	6.363"
2016.1	196.57°	6.32"

Table 2. Listed above are the averages of the Mean, Standard Deviation, and the Standard Error of the Mean from all 58 images taken through LCO.

Astrometric Results for HJ 2350		
SBIG 6303 0.4-meter		
(58) Images		
Filters: (43) R, (15) w		
Epoch 2018.832	θ (°)	ρ (")
Mean	195.76	6.24
Standard Deviation	0.4	0.04
Standard Error of Mean	0.05	0.005

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Table 3. Shows a breakdown of filter-types, and exposure times with the p and theta averages

Astrometric Results by Filter for HJ 2350		
SBIG 6303 0.4-meter (58) Images		
Epoch 2018.832	θ (°)	ρ (")
(15) rp , 0.5s	195.87	6.25
(14) rp, 1.0s	195.71	6.23
(14) rp, 1.5s	195.73	6.25
(15) w, 1.0s	195.71	6.24

Discussion

As Figure 3 indicates, the separation angle measured in this observation falls within the trend in the historical data displayed in Table 1, with a calculated standard deviation of 0.04", as seen in Table 2. The distance between *a* and *b* was determined by using the stellar parallax, from GAIA (2018), with the formula:

$$d = \frac{1}{p} \times 10^3$$

This calculation is with distance in parsecs (pc) and parallax in milliarcseconds (mas), thus requiring the scalar to convert to arcseconds (Williams College). The parallax for *a* was 2.662 ± 0.030 mas and *b* was 3.880 ± 0.032 mas (ESA, 2018). The result is a mean distance of 257.7 ± 8.299 pc to star *a* and 375.7 ± 11.27 pc to star *b*, implying a minimum distance of 117.9 pc between *a* and *b*.

Conclusion

We obtained measurements for the position angle and separation of the system HJ 2350, which were in line with the trend observed from the WDS historical data. However, from calculating distance between the stars from GAIA parallax data indicates that there would be a minimum of 117.87 pc between the stars. Therefore, we would we suggest a classification be appended from uncertain double to visual double.

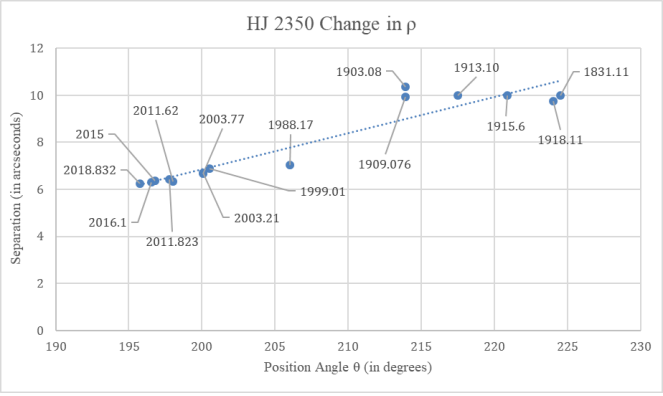

Figure 3. The change in ρ over time with the inclusion of the observations made in this study.

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