Observation and measurements for the Double Star System - HJ3203

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Abstract

The double system WDS 23352+1133 HJ 3203 was observed on October 17, 2023, with a 0.4m optical telescope from Las Cumbres Observatory (LCOGT). We compare the historical data with our measurements of position angle (PA) and separation (SEP).

1. Introduction

The observation of binary star systems is a key factor when studying stellar evolution, as they are used to determine the masses of stars (Fraknoi et al., 2022). This information can be acquired from observing and measuring their orbital dynamics (e.g. Genet et al., 2018). Our goal was to observe the double system HJ 3203 and make measurements of PA and SEP to contribute to having a more accurate determination of the nature of this system. In this paper we present a graph of a possible orbit, a table of historical data of the system and our new measurement of PA and SEP.

We selected HJ 3203 using the program Stelle Doppie and considering double star systems with apparent magnitudes between $9 < m < 11$ and $\Delta m < 3$. In 187 years 19 observations have been made of this system. The earliest observation was made in 1830 by the well-known English astronomer John Herschel, and the last observation was made in 2017. Table 1 shows the coordinates (2000.0) of HJ3203 and the apparent magnitudes of the stars in this system. Figure 1 shows an image of HJ3203 from the Digitized Sky Survey (DSS) obtained from the Stelle Doppie program. Figure 2 shows an example of the measurements made using AstroImageJ.

Table 1. Basic data of HJ 3203 system.

Name	RA (2000.0)	DEC (2000.0)	m_1	m_2
HJ 3203, WDS J23352+1133AB, Tycho 1172-00633-1, Gaia DR3 2762278305825570880	23h 35m10.365s	+11°32’42.8”	10.23	10.20

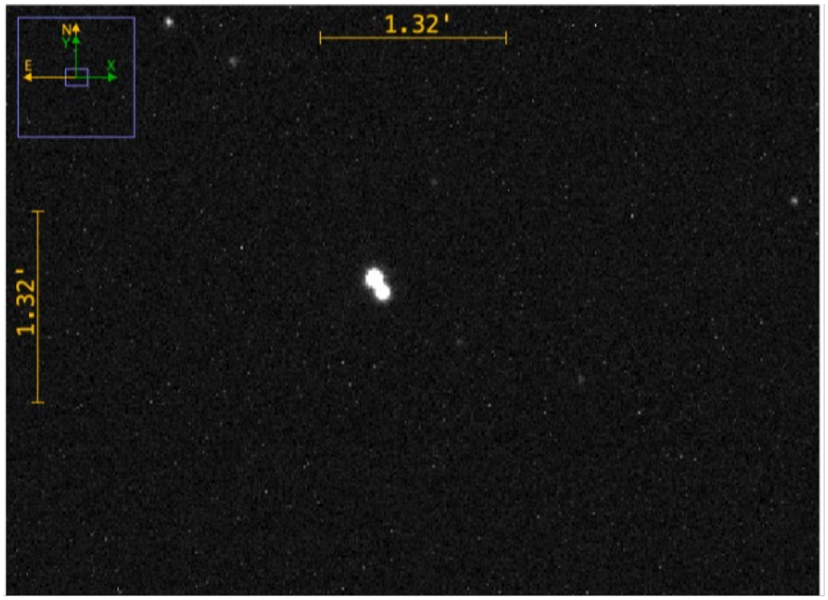

Figure 1: Image of HJ 3203 taken with a 0.4m optical telescope operated by LCOGT

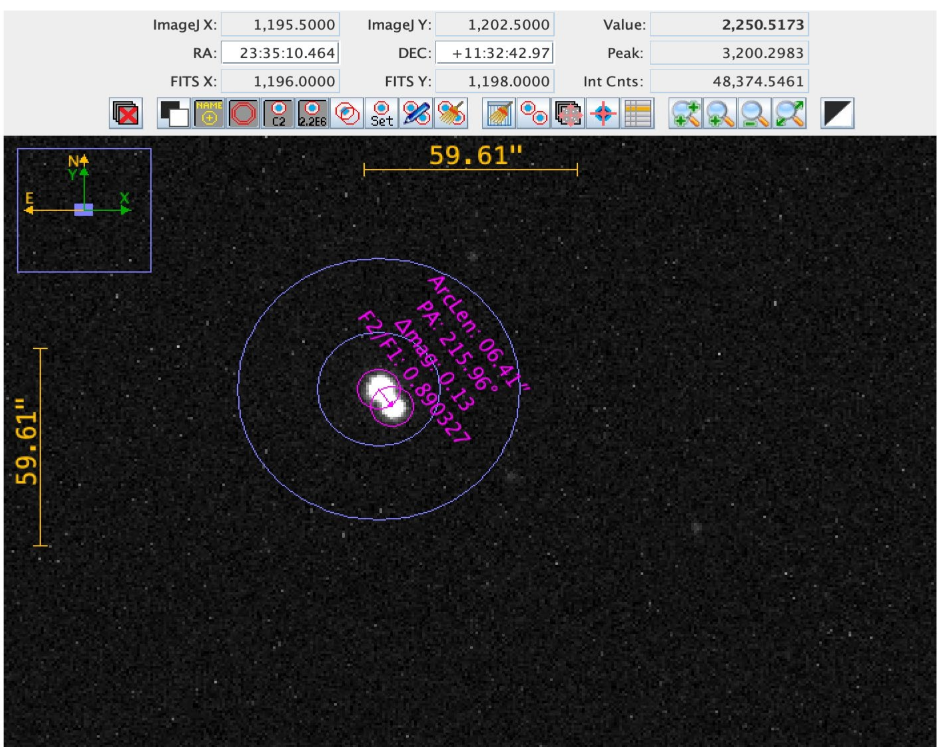

Figure 2: Example of measurements of HJ 3203 made using AstroImageJ

2. Equipment and Methods

The astrometric images of HJ 3203 were taken using a 0.4m optical telescope from LCOGT at the South African Astronomical Observatory (SAAO) and Haleakala nodes using a DeltaRho 350+QHY600 camera (field view of 30'x30'). The observations were submitted using the LCOGT observing portal.

3. **Data**

Table 2 presents the measurements of PA in degrees and SEP in arcsec for the images obtained with LCOGT. All images were taken with a Bessell-V filter and 2 seconds of exposure time.

Table 2. Data of system HJ 3203 observed with LCOGT.

Date	PA (deg)	SEP (arcsec)
oct.18.2023	207.57	6.04
oct.18.2023	212.89	6.48
oct.18.2023	211.38	5.79
oct.18.2023	214.12	6.71
oct.18.2023	207.56	6.59
oct.18.2023	215.96	6.41
oct.18.2023	215.4	6.06
oct.18.2023	215.96	4.27
oct.18.2023	215.12	5.89
oct.18.2023	211.38	6.52
Average	213	6.1
	Standard deviation PA (degrees)	3
	Standard deviation SEP (arcsec)	0.7

4. Discussion

We searched SIMBAD for information about the system, shown in Table 3. The primary star is also known as Tyc 1172-633-1 and Gaia DR3-2764227830582570880 in the Gaia DR3 catalog. We present in column 1 Parallax (mas), column 2 shows the error in Parallax (mas), column 3 contains the Proper Motion (PM) in RA (mas/yr), column 4 presents the error in PM in RA (mas/yr), column 5 is the PM in DEC (mas/yr), column 6 shows the error in PM in DEC (mas/yr) and column 7 contains the distance (pc). No information about the secondary star was found in Gaia DR3.

In Table 4 we present the PA and SEP for the historical data for the system HJ 3203. Column 1 lists the date, column 2 is the PA (degrees), column 3 is the SEP (arcsec), column 4 is the RA (arcsec) calculated as SEP x sin(PA), column 5 shows the DEC(arcsec) calculated as –SEP x cos(PA), column 6 is the aperture of the telescope (m) and column 7 shows the number of nights.

In Figure 3 we present the historical data plotted as a cartesian plot with the primary star at the origin and the secondary star represented by dots (blue is the historical data and red is our measurement). The x-axis is the RA (arcsec) and the y-axis is the DEC (arcsec). The plot suggests a curvature but shows a lot of scatter. The blue line is a second order polynomial fit to the data, the value of R2= 0.7. In Figure 3 we have labeled the four oldest observations: 1830.78, 1910.68, 1910.68, 1910.74. They all lie above the blue line with two of them very close to the polynomial fit (1830.78, 1910.74).

To explore the effect of the oldest points on the data we present Figure 4. It shows the motion as a cartesian plot with the primary star at the origin but it excludes the three earliest data recorded (1830.78, 1910.68, 1910.74). The plot in Figure 4 shows much more scatter and a lower correlation coefficient value (R^2=0.6). This is probably due to the oldest two points being very close to the polynomial fit in Figure 3.

A further test is shown in Figure 5 which shows the historical data excluding the 5 earliest data recorded (1830.78 , 1910.68 , 1910.68, 1910.74, 1912.85, 1912.93 excluded). The resulting polynomial fit has an R^2 = 0.7. Those 5 data points correspond to observations taken with 0.5m and 0.3m telescopes.

For our analysis of the system it is more appropiate to include all the historical data (the two oldest observations were made with 0.5m telescopes). Our results in Figure 3 indicate our double star system is consistent with a physical system.

It was found that the measurements obtained with AstroImageJ were sometimes different even using the same presets that can be modified in the Aperture Photometry Settings section of the AstroImageJ program. We found that when using the AstroImageJ program to determine data from the binary system, systematic errors on the part of the observer may be present. Factors such as the image quality can influence the observer's perception of the binary system. For binary pairs that are this close together, it can be more difficult to measure the separation.

Table 3: Data for Gaia DR3-2764227830582570880 – (HJ 3203)

Parallax (mas)	Error Parallax (mas)	PM in RA (mas/yr)	Error for PM in RA (mas/yr)	PM in DEC (mas/yr)	Error for PM in DEC	Distance (pc)
7.2030	0.0229	21.377	0.028	3.625	0.018	135.5746

Table 4: Historical data HJ 3203 from the WDS catalog.

Date	P.A. (degrees)	Sep (arcsec)	RA (arcsec)	DEC (arcsec)	Aperture (m)	#Nights
1830.78	206.4	5	-2.223	4.479	0.5	1
1910.68	209.1	6.55	-3.185	5.723	0.5	2
1910.74	207.1	5.484	-2.498	4.882	0.3	1
1912.85	209.2	6.661	-3.250	5.815	0.3	1
1912.93	209.7	6.865	-3.401	5.963	0.3	1
1986.8	210.8	5.57	-2.852	4.784	0.6	2
1988.924	212.8	6.52	-3.532	5.480	0.7	2

2000.72	211.3	6.54	-3.398	5.588	1.3	1
2000.814	211.1	6.5630	-3.390	5.620	1.2	4
2010.5	211.5	6.42	-3.354	5.474	0.4	1
2010.837	211.2	6.59	-3.414	5.637	0.7	2
2013.953	211.36	6.525	-3.396	5.572	0.2	3
2014.752	211.41	6.555	-3.416	5.594	0.2	8
2015	211.366	6.57	-3.420	5.610	1	1
2015.5	211.377	6.5721	-3.422	5.611	1	1
2016	211.38	6.573	-3.423	5.611	1	1
2016.826	210.9	6.586	-3.382	5.651	1	1
2016.924	210.7	6.54	-3.339	5.623	0.7	1
2017.9342	211.71	6.621	-3.480	5.632	0.3	1
2023.8	213	6.1	-3.322	5.116	0.3	1

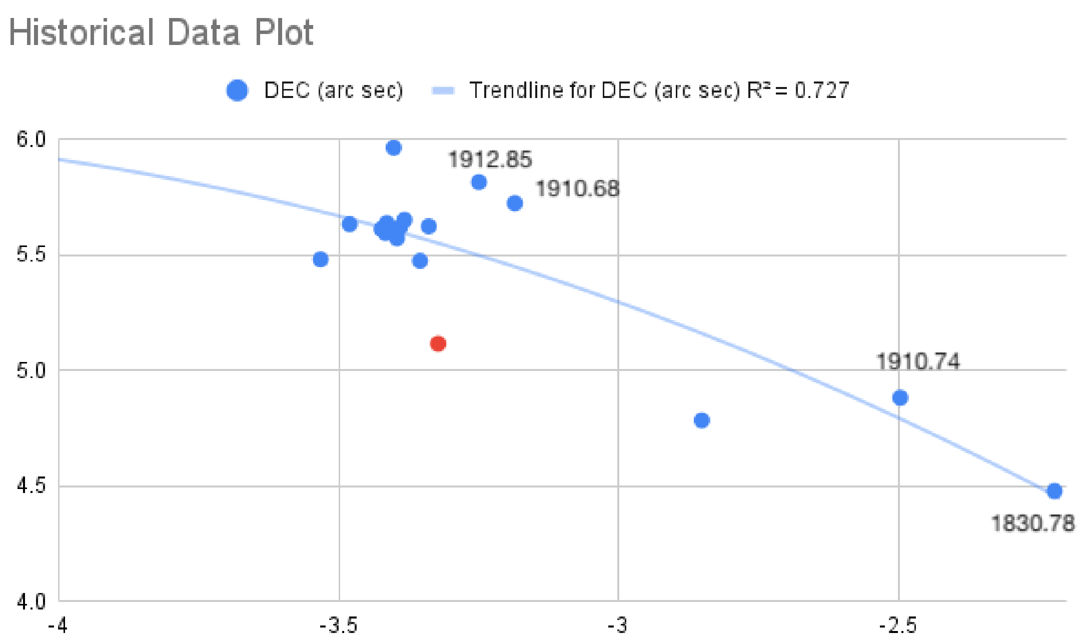

Figure 3: Plot for the historical data of HJ 3203 in a cartesian plane with the primary star in the origin. The horizontal axis represents the RA in arcseconds, and the vertical axis is the DEC in arcseconds. Blue is the historical data and Red represents our measurement. The oldest 4 observations have been labeled.

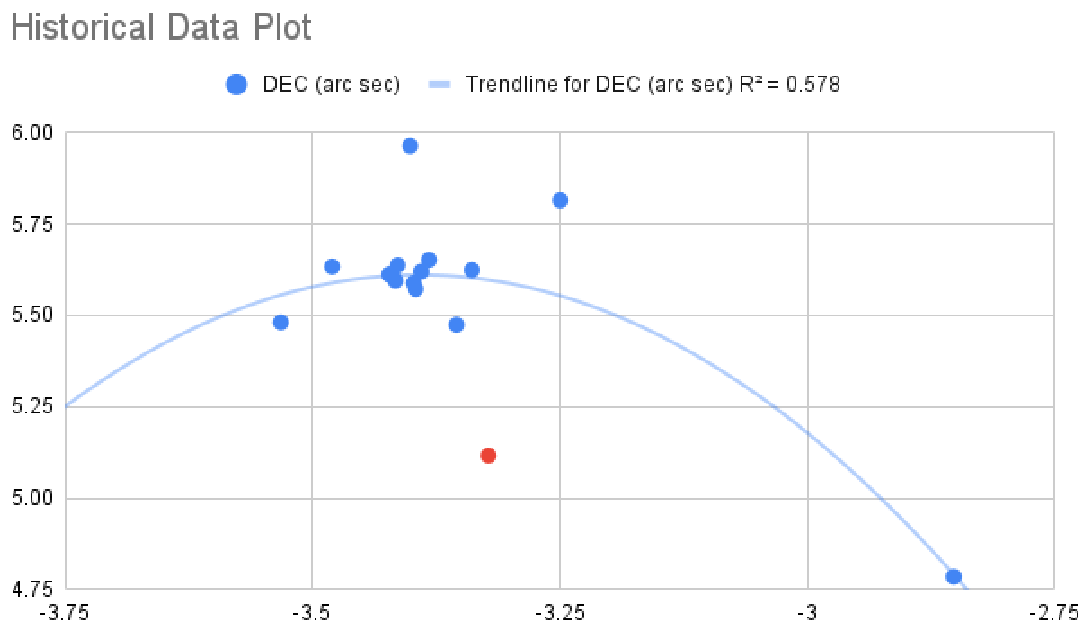

Figure 4: Plot for the historical data of HJ 3203 without the three oldest observations. The horizontal axis represents the RA in arcseconds, and the vertical axis is the DEC in arcseconds. Blue is the historical data and Red represents our measurement

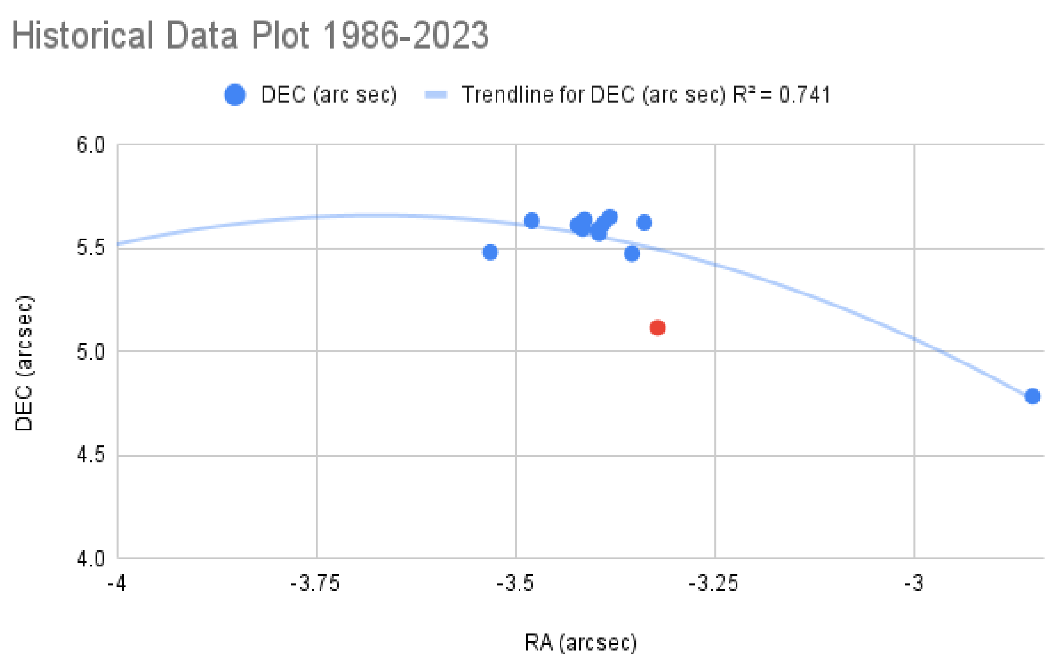

Figure 5: Plot for the historical data of HJ 3203 without the five oldest observations (time period 1986-2023). The horizontal axis represents the RA in arcseconds. Blue is the historical data and Red represents our measurement.

5. Conclusions

HJ 3203 seems to be a physical pair. More observations of the system would help prove that hypothesis. Our results in Figure 3 show a second order polynomial fit with $R^2 = 0.7$ moderately consistent with a physical system. Gaia DR3 catalog only had information regarding the primary star. Further observations are required to determine a more precise orbit for this binary system in which the stars have a small separation. More information about the secondary star is needed as well in order to determine and confirm the nature of HJ 3203 double star system.

6. Acknowledgements

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