Astrometric Measurements of WDS 17103-7523

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Abstract: The position angle and angular separation of WDS 17103-7523 (HJ 4904) were calculated using 15 images from Las Cumbres Observatory global telescope (LCOGT) and were found to be 188.17° and 6.83", respectively. When these measurements are combined with historical and Gaia Early Data Release 3 (EDR3) data, it is possible the source is a physical system. We include a short discussion about the separation of the components in system WDS 1722-3233 (PRO 171), although precise measurements could not be made.

1 Introduction

Binary stars are systems in which two stars that are gravitationally bound orbit about a common center of mass. Astrometric measurements of these systems allow for further information about the stars to be determined, such as the mass and other intrinsic properties. In this paper, we report new measurements of the position angle and separation of the primary and secondary components of the double system WDS 17103-7523 (HJ 4904). An observation of the separation of stars in WDS 17322-3233 (PRO 171) is also briefly presented. We discuss the selection of target sources in Section 2, our observations in Section 3, analysis of the data in Section 4, and the nature of the systems based upon current data in Section 5.

2 Source Selection

The Gaia Double Star Selection Tool (GDS) (Rowe, 2020) was used to limit the Washington Double Star Catalog (WDS) (Mason et al., 2001) to find target systems. Table 1 shows our criteria for target coordinates, magnitude (m), difference in magnitude (Δm), and separation (ρ).

Table 1: Source Selection Criteria

RA (J2000)	$11^h \rightarrow 21^h$
DEC (J2000)	-80°→ +80°
m	$6 \rightarrow 12$
Δm	$0 \rightarrow 3$
ρ	$5'' \rightarrow 10''$

Search results were filtered to systems that had not been observed since 2015. The Stelle Doppie Double Star Database (Sordiglioni, 2020) was used to narrow our results by validating the last date observed as reported by the WDS and ensure there has been a minimum change in position angle and separation of 5° and 1″, respectively, since discovery.

We chose to observe WDS 17103-7523 and WDS 17322-3233, as they fit the criteria from Table 1. WDS 17103-7523 was discovered in 1835 by John Herschel (Herschel, 1847) and has not been observed since 2015. WDS 17322-3233 was discovered in 1911 by Clive Nossiter (Nossiter, 1913) and has not been observed since 1998. These sources are especially interesting since the lack of recent observations allow for the possibility of large changes in position angle (θ) and separation (ρ) since last observation. As both sources have uncertain orbital natures, new measurements could reveal the true nature of these systems. Information about each of these sources from Stelle Doppie can be found in Table 2.

Table 2: Stelle Doppie Information

	WDS 17103-7523	WDS 17322-3233
RA (J2000)	$17^h\ 10^m\ 16.34^s$	$17^h\ 32^m\ 8.32^s$
DEC (J2000)	-75° 22′ 35.6″	-32° 34′ 10.8″
First Obs., Last Obs.	1835, 2015	1911, 1998
m_A, m_B	7.56, 9.13	12.5, 12.8
Last observed θ	188°	356°
Last observed ρ	6.8″	5.3″
$\Delta\theta$ since discovery	5°	24°
$\Delta\rho$ since discovery	3.8″	1.1″

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3 Observations

The 0.4 m Las Cumbres Observatory global telescope (LCOGT) (Brown, 2013) at the Cerro Tololo Inter-American Observatory was used to observe our sources. The SBIG STL-6303 CCD camera imaged both systems with the clear filter. Fifteen images of WDS 17103-7523 were taken 2021 May 28 with an exposure time of 1 second. One image was taken 2021 June 13 of WDS 17322-3233 with an exposure time of 4.5 seconds due to the large magnitudes of the stellar components. Further imaging of this source was not performed after inspection of the first image. This is further discussed in Section 5.

4 Analysis

Images were calibrated and reduced by the LCOGT pipeline (Fitzgerald, 2018) for both sources. The aperture photometry tool of AstroImageJ (Collins et al., 2017) was used to measure the position angle (θ) and separation (ρ) on each of the 15 images of WDS 17103-7523. The Howell centroiding method (Howell, 2006) was used to find the center of the stars. These measurements are shown in Table 3 along with the average, standard deviation, and standard error of the measurements. An example measurement of Image 1 in AstroImageJ is shown in Figure 1. AstroImageJ was also used to create an average intensity stack of the 15 images, and the separation and position angle of the stack was measured to be 6.82″ and 187.09°, respectively. These are in close agreement with the average of the individual images.

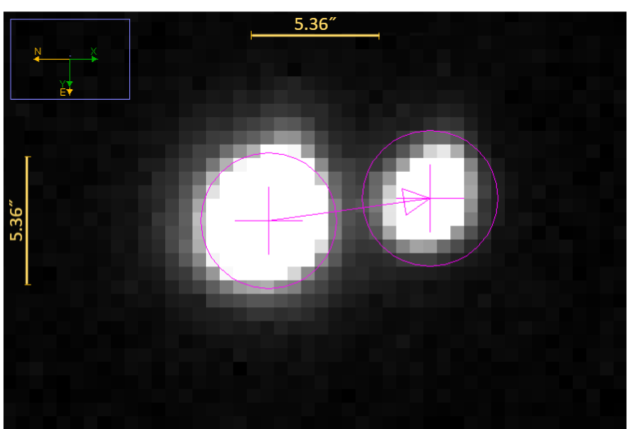

Figure 1: WDS 17103-7523 as seen in AstroImageJ. The purple circles are the aperture photometry tool, and crosses are the center of the stars as determined by the Howell centroiding method. The separation was measured as 6.82″ and the position angle was 188.36°.

Table 3: Position Angle and Separation for WDS 17103-7523

Image Number	Separation (″)	Position Angle (°)
1	6.82	188.36
2	6.80	187.78
3	6.83	188.35
4	6.89	188.23
5	6.90	188.79
6	6.82	188.19
7	6.91	188.03
8	6.80	187.47
9	6.76	187.76
10	6.87	188.75
11	6.83	188.10
12	6.77	187.72
13	6.86	187.70
14	6.83	189.06
15	6.76	188.28
Averages:	6.83	188.17
Standard Deviation:	0.05	0.45
Standard Error:	0.01	0.12

The single image of WDS 17322-3233 was also viewed in AstroImageJ and is shown in Figure 2. The top panel in the figure shows the target in the center and a field of view of 56″ by 38″ in the neighborhood of the system. As reported by Stelle Doppie and shown in Table 2, the last observed separation of the two stars in the system was 5.3″. The two stars of the double star system cannot be seen individually, although the field is large enough to show both components. If the current separation is above 5″, both the primary and secondary stars would be resolvable by the SBIG STL-6303 CCD camera. Since both components cannot be seen, the separation must have decreased, resulting in both components becoming unresolvable. The bottom panel of the figure shows a smaller field of view of 14″ by 9″. In this image, both stars appear to lie within the ≈3″ apparent width of the target. As the components are not resolvable by the LCOGT, the current separation must be below 5″. We are therefore unable to report new measurements of position angle and separation. We believe this source is a good candidate for speckle interferometry in future observations to achieve higher resolution.

5 Discussion

Historical data was requested for WDS 17103-7523 from Dr. Brian Mason of the United States Naval Observatory (USNO) to be compiled with our data. Historical observations containing position angles and separations are presented in Table 4. The measurements in this table are given to the precision reported in the respective references.

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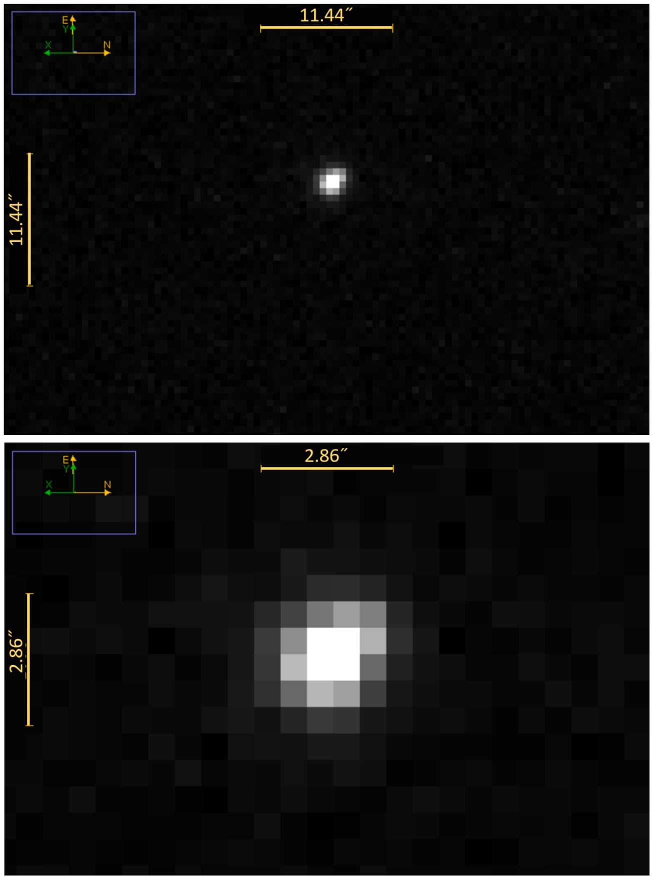

Figure 2: WDS 17322-3233 as seen in AstroImageJ. The top panel shows a field of view of 56″ by 38″ and the bottom panel shows a narrow field of 14″ by 9″. The two components of the double star system were not resolved.

The first two observations have separations that are outliers, as the stars could not have changed from 3″ to 10.4″ in 16 years based on the rest of the historical data. The outliers will be omitted from our analysis. The position angle and separation as a function of time can be seen in Figure 3, excluding the first two observations. These plots show that there is a large variance in both position angle and separation as functions of time. If the system is binary, it is expected that the position angle and separation increase and decrease over the period of one orbit. The WDS reports a period of 8152.56 years for this source. This source has only been observed for 186 years, which is only about 2% of its reported period. Therefore, the random variance in the data reflects the precision of measurements.

The historical data was converted into Cartesian coordinates and the position of the secondary star relative to the primary was plotted using The Plot Tool 3.19 (Harshaw, 2020). This plot is shown in Figure 4. Due to the variance in position angle and separation, the data appears scattered in the spatial plot. Since there is no trend, an orbit cannot be calculated for this system based upon current observations.

Table 4: Historical Data for WDS 17103-7523

Obs. Date	θ (°)	ρ (″)	Reference
1835.39	183.2	3	Herschel (1847)
1851.54	183	10.4	Gilliss (1868)
1872.49	183.5	7.11	Russel (1871)
1892.57	191.3	7.981	Urban et al. (1998)
1894.49	190.2	7.176	Urban et al. (1998)
1901.59	187	7.07	Innes (1905)
1918.67	188.1	6.88	Dawson (1922)
1940.38	187.2	7.46	Geddes and Thomsen (1940)
1947.6	187.3	7.135	Stoy (1966)
1956.42	192.4	6.624	Lü (1971)
1957.553	186.89	6.722	Kamper (1985)
1987.356	185.65	6.78	Sinachopoulos and van Dessel (1998)
1991.25	186.6	6.749	Hipparcos (1997)
1991.48	186.7	6.75	Fabricius et al. (2002)
1998.29	186.7	6.814	Hartkopf et al. (2013)
2000.3	187.3	6.81	2MASS Catalog (2003)
2010.5	186.7	6.53	Cutri et al. (2012)
2015	188.307	6.816	Knapp and Nanson (2018)
2021.4	188.17	6.83	present work

The Plot Tool was also used to determine the distance to the stars using Gaia Data Release 2 (DR2) and Early Data Release 3 (EDR3) data. These values are shown in Table 5. Note that the distances to the secondary component are not in agreement between Gaia DR2 and EDR3. While Gaia DR2 measurements suggest that the stars in WDS 17103-7523 are distant from each other, Gaia EDR3 data indicate that they are closer together. The distances shown by Gaia EDR3 data increases the probability that the system is physical.

Table 5: Gaia Distances

	Gaia DR2	Gaia EDR3
Distance, Star A (pc)	83	81
Distance, Star B (pc)	112	82

In addition to this, the Plot Tool was used to calculate the expected relative positions of the system components based on proper motion data from Gaia EDR3. These expected positions were compared to the motion shown by historical observations. The separation and position angle by proper motion are 0.72″ and 259.66°, respectively. Historical data shows that they are 0.63″ and 302.06°. While the values are not in complete agreement, they are similar and we therefore cannot rule

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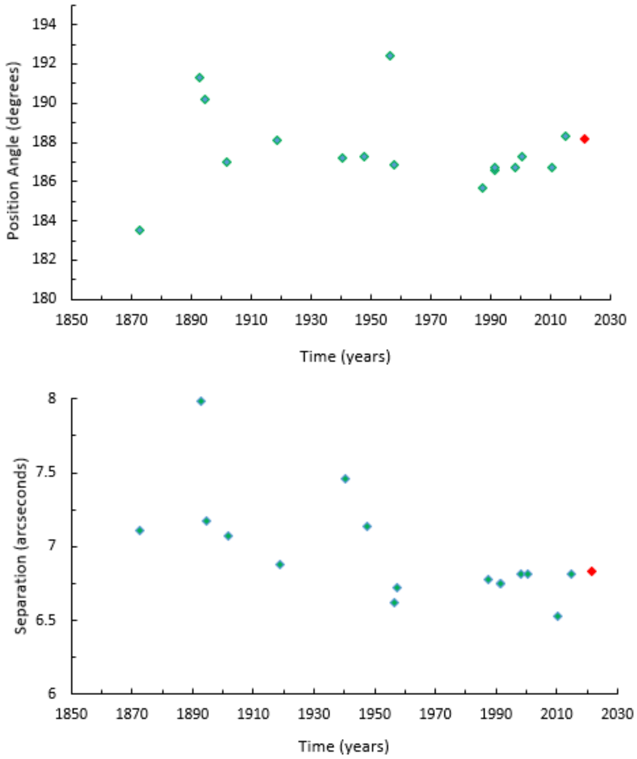

Figure 3: Observed position angles (top) and separations (bottom) as a function of time, both excluding the first two historical observations. The historical data is in green, and our data point is in red.

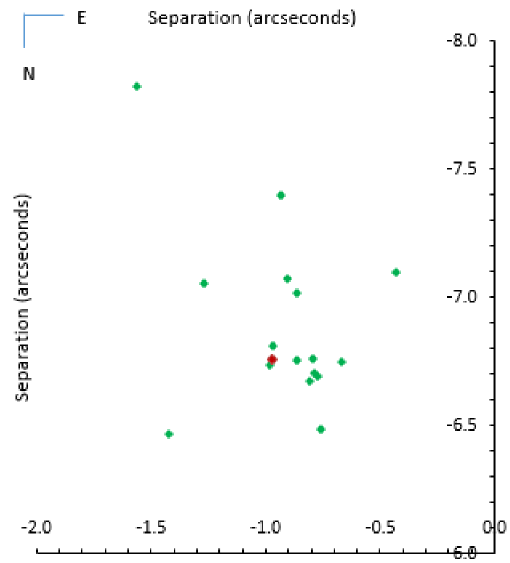

Figure 4: Angular separation of star B relative to star A at the origin (off screen, bottom right). The historical data is in green, and our data point is in red.

out the possibility of them being a proper motion pair.

In this paper, we report new observations of the position angle and separation of WDS 17103-7523 as of 2021 May 28. We were unable to determine the nature of the source. WDS 17322-3233 was recommended to be studied with speckle interferometry due to the inability of the LCOGT 0.4 m telescopes to resolve the components of the double star system.

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