Measuring the Position Angle and Separation of WDS 0063-6414

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Abstract: Astrometric measurements of the position angle and separation of the double star WDS 00063-6414 (I 433) were made using images taken on 30 September 2020 with a 0.4 m telescope in the Las Cumbres Observatory global telescope network (LCOGT) located at the Sutherland site of the South African Astronomical Observatory (SAAO). Measuring the 2020 observations yielded a separation of 5.65 arcseconds and a position angle of 135.34 degrees.

Introduction

Best known for discovering Proxima Centauri in 1915 (Glass, 2007, p. 39), Robert T.A. Innes discovered WDS 00063-6414 (entry I 433 in his double star catalogue), in 1907. Starting with a pre-discovery observation in 1892 and last observed in 2015, WDS 00063-6414 has been observed 17 times. This pair, located in Tucana, was observed by Gaia and the similarity of the proper motions and parallaxes indicate that this double is in fact physical, but there is no orbital data on the system yet. The primary is an F3IV and is also identified as HD 160 (HD 160, n.d.).

A list of double star candidates was first generated using Dave Rowe's *Gaia Double Star Selection Tool.* This initial search yielded a list of 422 potential candidates for study, with WDS 00063-6414 ultimately selected as it satisfied the criteria of magnitude differential and separation and had not been observed since 2015.

Methods & Materials

Once a target was selected, ten images were then requested through the LCOGT queue (Brown et al., 2013, p. 1042) and subsequently captured with a SBIG STL-6303 CCD camera at the LCO Sutherland site in South Africa using a clear filter on a 0.4 m telescope. Given the known magnitudes of the primary and secondary stars to be 8.03 and 10.17 respectively (*WDS 00063-6414 I 433,* n.d.), an exposure time of 3 seconds was initially chosen (actual image exposure 3.284 s) which ultimately provided sufficient signal to noise. The raw images were calibrated using the Our Solar Siblings Pipeline (Fitzgerald, 2018) and it was these calibrated images that were used in the analysis.

The software *AstroImageJ* (Collins et al., 2017, p. 77) was used to measure the position angle (θ) and separation (ρ) for each image (see Figure 1). The average value was then calculated along with standard deviation and standard error of the mean (see Table 1).

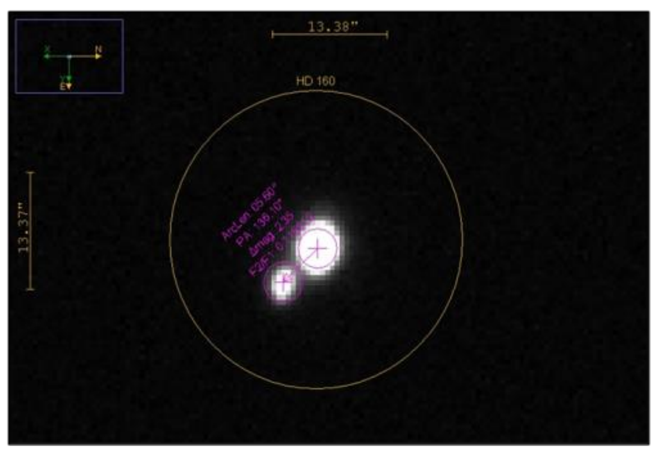

Figure 1: Shown here is one of the observations displayed in AstroImageJ. Also shown is the automatic centroiding of the program and the measurement of the position angle and the separation.

Data & Results

The ten images of WDS 00063-6414 taken at the LCOGT Sutherland site were each measured to find the separation and the position angle of the binary. The average separation was 5.65 arcseconds and the average position angle was 135.34 degrees, as seen in Table 1.

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WDS 00063-6414 10x 3.28 Second 2020-09-30 UTC 17:51		
Image	**Separation (″)**	**Position Angle (°)**
1	5.66	135.17
2	5.62	135.37
3	5.60	136.09
4	5.63	135.33
5	5.72	135.36
6	5.51	135.08
7	5.68	135.31
8	5.69	135.55
9	5.69	135.34
10	5.73	134.80
Means	5.65	135.34
Standard Deviations	0.07	0.33
Stand Errors of the Means	0.02	0.11

Table 1: Data collected on WDS 00063-6414 from LCOGT telescopes and measured using AstroImageJ.

In addition, historical data (shown in Table 2) were requested and obtained on this system from Dr. Brian Mason at the United States Naval Observatory. Using Plot Tool (Harshaw, 2020, p. 394), the historical data along with the current observation were plotted together in Figure 2. Plot Tool also adjusts for the Earth's precession to ensure all the positions are plotted for the same epoch. In Figure 3, some of the observations were removed to see if the plot would start to show any pattern. The data removed were the observations taken using a micrometer along with the first data point, WFC1998 Pa, which was clearly an outlier. Removing the first three older and presumably less accurate data did clean up the plot, but still failed to yield any evidence of a recognizable orbit.

In order to look at the data in a different way, plots were made of the observation year versus separation and versus position angle. Although plots were made with the same truncated data (and also excluding the data from 1993 due to a lack of precision in the observation date), only the plots which include all of the historical data are shown as Figures 4 and 5.

Year	Theta	Rho	Made By	Type
1892.78*	130.2	5.429	WFC1998 Pa	Photo*
1907.8*	135.	4.0	I__1909 Ma	Micrometer*
1911.38*	137.1	5.42	I__1912 Ma	Micrometer*
1926.84*	135.5	5.76	Fin1929a Ma	Micrometer*
1926.89*	135.0	5.67	B__1928b Ma	Micrometer*
1953.87	134.81	5.711	Lem1958 Po	Photo
1961.821	134.7	5.74	vAd1983 Po	Photo
1978.209	134.81	5.741	vAd1985 Po	Photo
1991.25	134.6	5.737	HIP1997a Hh	Satellite (Hipparcos)
1991.45	134.6	5.73	TYC2002 Ht	Satellite (Tycho)
1991.787	134.6	5.44	War1992b Ma	Micrometer*
1991.8	134.78	5.748	Cuy1999 C	CCD
1993	136.24	5.78	Bau2007 C	CCD*
1998.535	134.7	5.799	UC_2013b Eu	CCD (UCAC3)
2000.57	134.6	5.67	TMA2003 E2	CCD (2MASS)
2015.0	134.804	5.758	Kpp2018m Hg	Satellite (Gaia)
2015.5	134.80	5.7583	Gai2018 Hg	Satellite (Gaia)
2020.748	**135.364**	**5.653**	**TeamZeta - InStar**	**CCD**

*Table 2: The historical observations of WDS 00063-6414. Data marked with an * are observations that were not plotted in Figures 3 and 6. Those data are either micrometer measurements or obvious outliers.*

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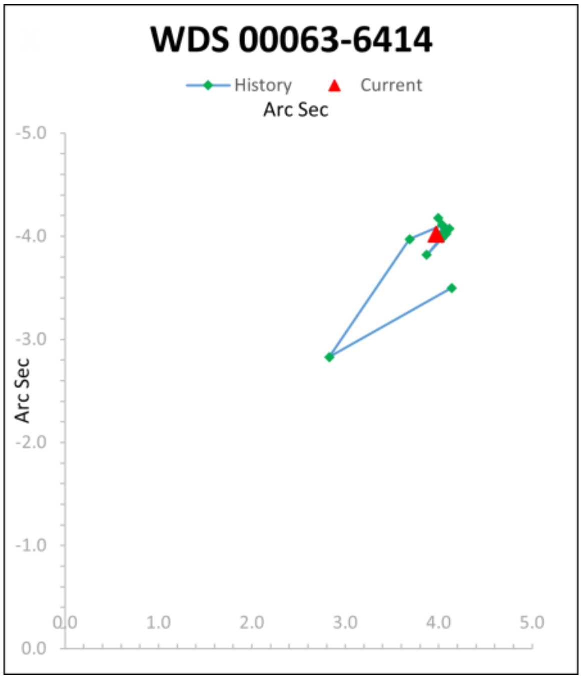

Figure 2: All historical data along with the current observation shown together. The current observation is shown as a red triangle.

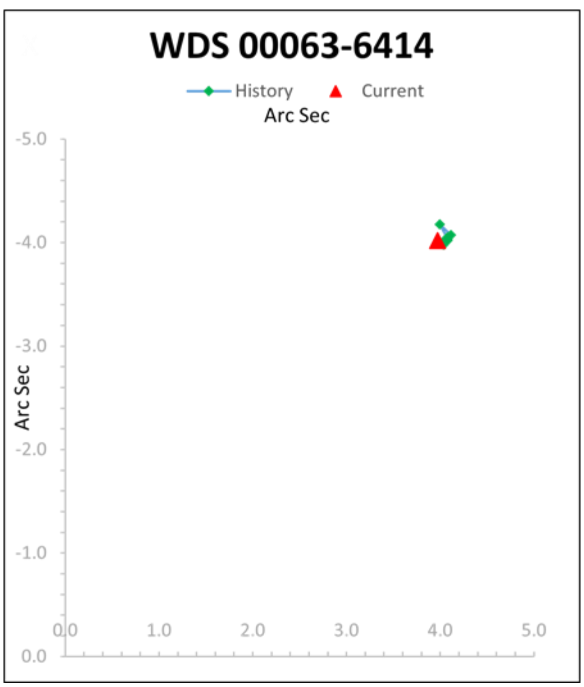

Figure 3: Historical data along with the current observation are shown but observations made using a micrometer and other outliers were removed. (Same scale as Fig. 2. See Fig. 6 for enlarged scale.

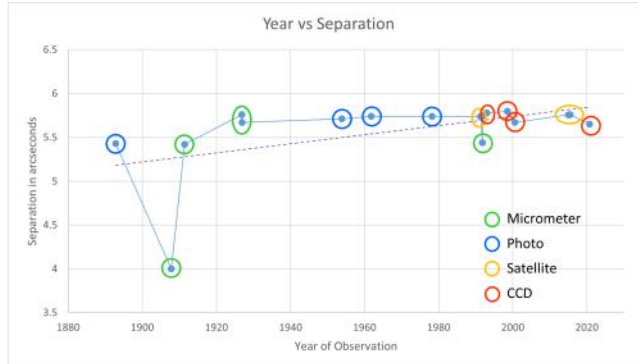

Figure 4: This plot shows the year of observation versus the separation of all of the historical data and the latest observation. The angle does not appear to have any measurable change. Given the small separation of 5.65" arcseconds, a small error of 0.1 arcseconds in the centroid of one of the stars could yield a change as large as 1 degree. Note that each observation is circled with colored markers showing the type of observation made.

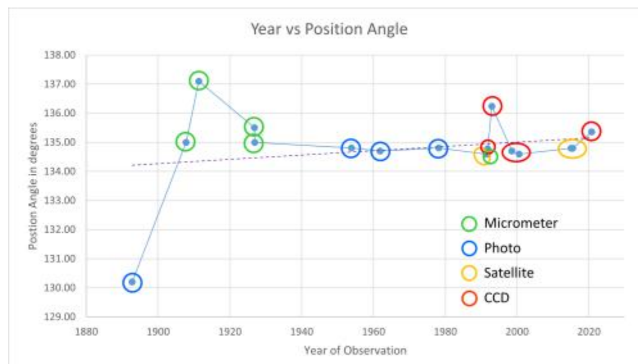

Figure 5: This plot shows the year of observation versus the position angle of all of the historical data and the latest observation. The total difference of the separation in the data, peak to valley, is 0.15 arcseconds. So, while the differences in the observations look significant, they are more likely in the noise of our observation.

Proper motion RA A (mas/yr)	Proper motion Dec A (mas/yr)	Proper motion RA B (mas/yr)	Proper motion Dec B (mas/yr)	Parallax A (mas)	Parallax B (mas)
34	15	35	15	4.17	4.24

Table 3: Data from the Gaia Double Star Catalogue. Given the similarity of the proper motion both in right ascension and declination along with the parallax of the components in the double star system WDS 00063-6414, the system is believed to be physical. Credit: ESA/Gaia/DPAC

Discussion

Initial examination of the plot of historical positions revealed what appeared to be a tangled or spiraling motion of the secondary star. (The primary star in Figure 2 is located in the bottom-left corner at the origin.) When magnified, the densest patch of observations is still seen to have no particular directionality to it.

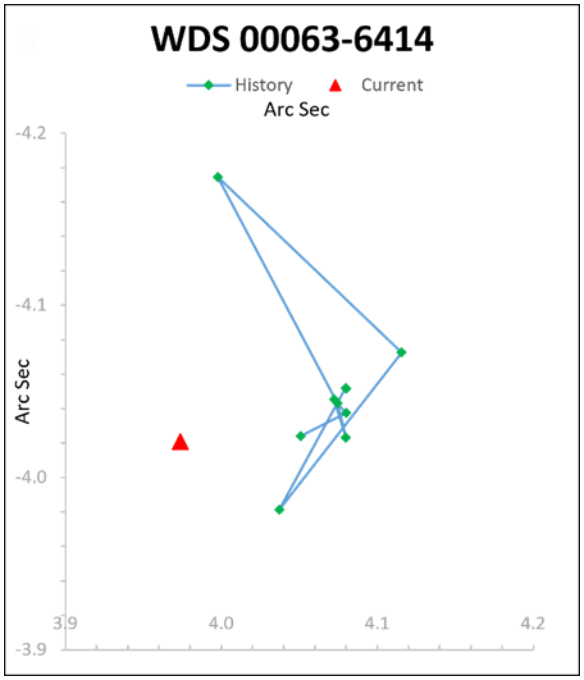

Figure 6: Historical data along with the current observation are shown but observations made using a micrometer and other significant outliers were removed.

In an attempt to make some sense of what the historical records show, measurements using a micrometer (presumably less reliable) were removed, leaving only various photographic methods (plate, film, CCD, and satellite-based CCD). An observation reported by the Washington Fundamental Catalog (WFC) from a photo dated to 1892, before the system's first published observation by Innes, was also removed. Although the source was photographic, this record was a dramatic outlier from the others, with a position angle of 130.2°, whereas the rest range somewhat smoothly between 134.6° and 137.1°.

With these data removed, the remaining historical measurements and the present measurement span roughly one-tenth of an arcsecond in right ascension and two-tenths in declination over a time interval of 67 years. Furthermore, the measurements follow no discernible pattern. Simple plots of separation versus time and position angle versus time similarly show no clear trend.

Put together, this all suggests that the differences in measurements are due largely to noise in the observations rather than motion within the WDS 00063-6414 system itself.

Despite this apparent lack of relative motion in the historical and current data, the Gaia observations, as shown in Table 3 above, indicate the components have similar proper motion and parallax. This, along with their transverse distance as computed by Plot Tool of 1,369 AU, all suggests that the stars are physically related, as already noted in the Stelle Doppie Database (WDS 00063-6414 I 433, n.d.).

Conclusion

The position angle and separation of the components of WDS 0063-6414 I 433 were measured using images taken with one of the LCOGT 0.4 m telescopes located at The South African Astronomical Observatory. When measured, the 2020 data yielded a separation between the two stars of 5.65 arcseconds and a position angle of 135.34 degrees. Although Gaia data suggests that this double is physical, the data collected neither confirmed nor repudiated that finding and instead serves to contribute to the collection of historical data for this double star.

Acknowledgments

The authors would like to thank Dr. Brian Mason of the United States Naval Observatory for providing the historical stellar data, Dave Rowe for his *Gaia Double Star Selection Tool*, and Richard Harshaw for the use of his *Plot Tool*. Finally, we would also like to extend our utmost gratitude to Rachel Freed, for providing feedback and encouragement through her amazing program.

This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory.

This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France.

This work has made use of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.

This research has made use of the VizieR catalogue access tool, CDS, Strasbourg, France (DOI: 10.26093/cds/vizier). The original description of the VizieR service was published in 2000, A&AS 143, 23.

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