Astrometric Analysis of Double Star System WDS 01180-0420 STF 111

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Abstract: Astrometric measurements were taken of the system WDS 01180-0420, first observed in 1827, to determine its nature, physical or non-physical. These measurements were made with images taken from the Las Cumbres Observatory telescope network with an SBIG STL-6303 camera on a 0.4-meter telescope. The measured position angle, theta, θ, 329.95° (standard deviation of 0.82°), and separation, rho, ρ 20.82″. (standard deviation of 0.21″), were consistent and linear when compared to the historical data obtained from the United States Naval Observatory. The primary and secondary stars have very similar parallaxes of 7.6412 mas and 7.9254 mas respectively, (GAIA) suggesting physicality. However, a significant difference in the proper motion, with values of 37.440 mas/yr and 45.812 mas/yr in right ascension and -10.477 mas/yr and -8.701 mas/yr in declination, indicate a potential lack of physicality.

Introduction

The objective of this research is to determine whether the star WDS 01180-0420 is a visual double star or a gravitationally bound system. By analyzing the separation (rho), in arcseconds, and the position angle (theta), in degrees, over time, the type of system and the possible orbit of the stars in the system can be determined.

The first observation of the system, made by John Herschel (Royal Astronomical Society, 1840), was in 1827 with a position angle of 320 degrees and separation of 17 arcseconds. This observation was reported in *Memoir: Volume 11 by the Royal Astronomical Society*. It was a part of the First Cambridge Catalogue of 726 Stars (Royal Astronomical Society, 1840). The system was last observed in 2015, with a position angle of 329 degrees and separation of 20.8 arcseconds, by Nanson and Knapp (2018). This system was observed 21 times over the past 192 years (GAIA). The spectral magnitudes and classification of the primary and secondary stars are shown in Table 1 below. (GAIA, Stelle Doppie).

	G mag.	BP mag	RP mag	Classification
Primary	9.2989	9.5727	8.9016	F7V
Secondary	10.2897	10.6473	9.8029	G5V

Table 1: Magnitudes and classifications of the primary and secondary star in WDS 001180-0420

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Materials and Method

The Boyce-Astro Research Assistant DoubleSTARS Query program (Hewett et al.), along with the Washington Double Star Catalogue and Stella Doppie were utilized to select a double star for study. The criteria for a potential star included an RA between 060000 and 080000 hours, a declination between -85 and 85 degrees, a separation between 5-20 arcsecs, a magnitude range of 9-11, and a delta magnitude of 3 or less, based on the limitations of the telescope network being used. A maximum of 100 observations, with none later than 2015 were included as criteria in order to ensure that the selected system could still use more observations. Using these criteria, the system WDS 01180-0420 was chosen. Next, a request was made using the Las Cumbres Observatory (LCO) online portal to obtain photos of the selected double star. Data was gathered on a 0.4-meter telescope with an SBIG STL-6303 camera from the Siding Spring Observatory in New South Wales, Australia. Ten photos of the system were taken on October 18, 2019, 2458776 BJD, at an exposure time of 2 seconds and with a red filter. The data was compared to past observations in order to track the movement of the star. Based on these observations, it can be determined whether the star is a visual double star or a gravitationally bound binary.

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Data

The position angle and separation were measured using the astrometry tool in AstroImageJ. A screenshot from one measurement is shown in Figure 1. The measurements for each of the 10 images, as well as the mean, standard deviation and standard error of the mean are provided in Table 2.

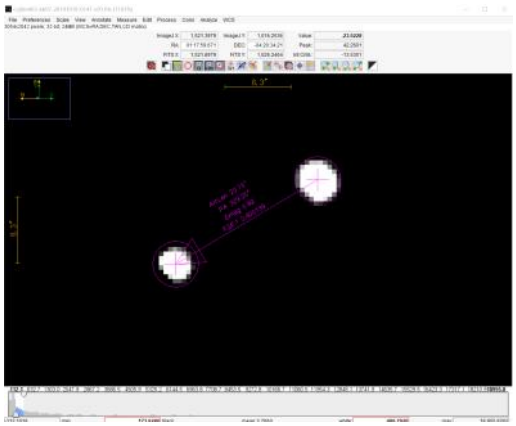

Figure 1: A screenshot showing the measurement of position angle and separation in AstroImageJ on an image obtained from the Las Cumbres Observatory telescope at Siding Springs, Australia.

Number	Time	Position angle (degrees)	Separation (arcseconds)
1	13:06:20	330.61	21.00
2	13:06:37	329.82	20.51
3	13:06:53	329.81	20.51
4	13:07:10	329.93	20.57
5	13:07:28	330.61	21.00
6	13:07:44	330.60	21.01=
7	13:08:00	330.61	21.01
8	13:08:17	330.63	21.02
9	13:08:33	328.47	20.80
10	13:08:49	328.45	20.81
Mean		**329.95**	**20.82**
Standard Deviation		0.82	0.21
Standard Error of the Mean		0.26	0.07

Table 2. Position angle and separation measurements made by the Oxbridge team from LCO data acquired on 18 October 2019 with an exposure time of 2 seconds.

Analysis

Using the program AstroImageJ (2019), measurements of the position angle and separation were taken from each image provided by the telescope. As shown in Table 2, the mean position angle (329.95°) and separation (20.82 arcsecs), standard deviation, and standard error of the mean were calculated from the data.

The data collected was compared with historical data obtained from the US Naval Observatory (USNO) and is shown in the graphs below (Figures 2-5). Figure 2 shows the separation of the system, in arcsecs, since the year it was discovered, including the new measurement found in our observation (the red point). Figure 3 also shows the separation, but without outliers, including the new measurement. Figure 4 shows the position angle of the system, in degrees, since its discovery, including the new measurement found in our observation. Figure 5 also shows the position angle, including the new measurement, and with outliers omitted. Two points from the years 1827 and 1840 from the position angle data and three points from the separation data were omitted as they are considered outliers. Their lack of linearity with the other points indicates that there was error in the process of making those observations, as shown in Figures 3 and 5. Compared to the data that follows, the omitted measurements didn't follow the linear trend of the others. As a result, the first two measurements of the position angle and the first three measurements of the separation can be considered outliers.

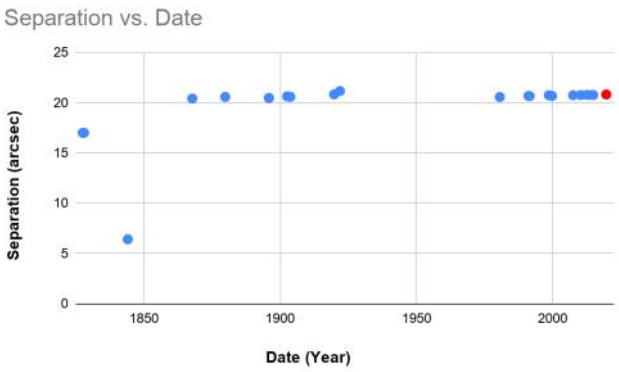

Figure 2. Separation in arcsec and date in years for WDS 01180 -0420, including historical data and new measurement (red dot).

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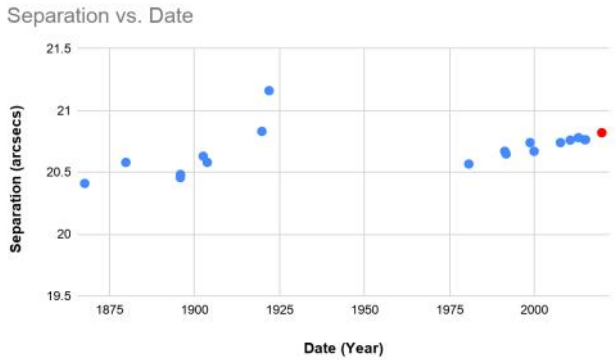

Figure 3: Separation in arcsec and date in years for WDS 01180-0420 (without outliers), including historical data and new measurement (red dot).

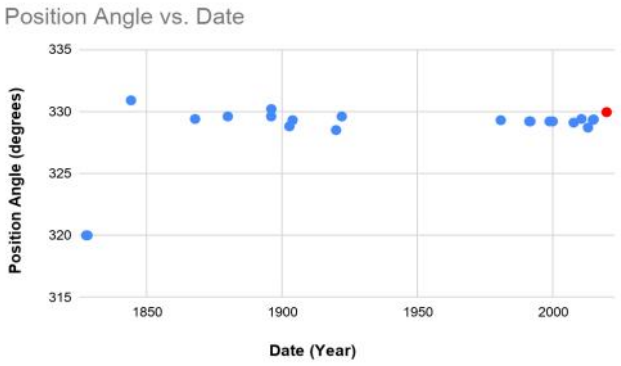

Figure 4. Position Angle in degrees and date in years for WDS 01180-0420, including historical data and new measurement (red dot).

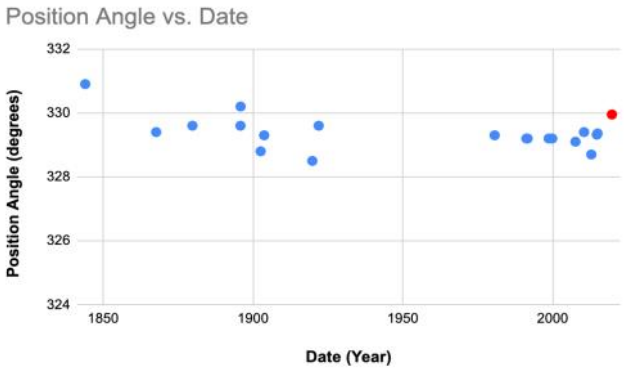

Figure 5. Position Angle in degrees and date in years for WDS 01180-0420 (without outliers), including historical data and new measurement (red dot).

The data shows a lack of change in the separation and position angle, giving no indication of a short arc in almost two centuries, making the determination of whether the system is binary more complex. By looking at the parallaxes of both the primary and secondary stars, they are very similar, at 7.6412 mas and 7.9254 mas respectively (GAIA). Despite this, similar parallaxes are not definitive in determining the system's physicality. This historical data was plotted in Cartesian coordinates in Figure 6, below, using Richard Harshaw's Plot Tool (Harshaw, 2020). Again, no indication of an arc is seen in the data.

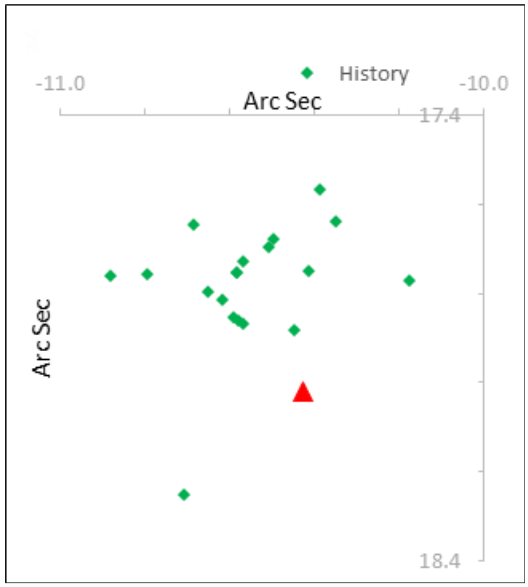

Figure 6: Plot of the measurement history of WDS 01180-0420

Discussion

Historical data for the position angle and separation measurements of WDS 01180-420, obtained from the United State Naval Observatory, were graphed, along with the newest measurement. The graphs of this system show a lack of change in the position angle and separation, making initial determination of physicality harder to conclude. The red point in each graph indicates the most recent observation taken in October 2019 and matches closely with the data taken over the past 150 years.

Conclusion

The final data shows that the primary and secondary stars of WDS 01180-420 have very similar parallaxes and a significant difference in the proper motion. Although the proper motion isn't enough to denounce physicality, the lack of change in the separation and position angle supports this idea. While it is rare, however, there is a small possibility that a binary system with significantly different proper motions that is similar to this system exists. The position angle and separation of the two stars remained constant relative to the historical data from the United States Naval Observatory. Further research can be conducted on this system by measuring and comparing the escape velocities of the two stars in order to further clarify any possibility of

physicality in this system. Despite the lack of physicality, the similarity in the parallax values could lead to the possibility that the stars in the system were created by the same cloud of gas and dust. Further study into the chemical makeup of the stars could shed light on this possibility. Although the physicality of the system is still questionable, the observations made could later contribute to the determination of the path of the system if it is declared physical.

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