Astrometric Measurements of Double Star System WDS 18166+8027

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Abstract: Observations were made of the double star system WDS 18166+8027 (LDS1884). To date, WDS 18166+8027 has been observed only five times since its discovery in 1965. In this sixth study, CCD measurements were made using the Las Cumbres Observatory Global Telescope Network (LCOGT) and recorded a position angle of 107.79 +/- 0.46 degrees and a separation of 5.72 +/- 0.09 arcseconds. Recent observations of this pair have brought into question the original measurement of this double star by Willem Luyten, and parallax measurements from the Gaia survey indicate that the stars may not be close enough to each other to be in a gravitationally bound orbit. Further measurements are needed to determine whether this system is a physical binary or optical double.

Introduction

The scientific study of double stars offers a sizable professional-amateur collaborative community of research (Genet et al., 2018). The system chosen fits the following criteria: (i) a separation greater than five arcseconds, (ii) the primary star must have a maximum magnitude of seven, and (iii) the delta magnitude has to be three or less. Based on these parameters WDS 18166+8027 (LDS1884) was investigated and an image of this system taken from LCO is shown in Figure 1. The binary star system WDS 18166+8027 is located within the northern constellation Draco near the North Celestial Pole (see Figure 2).

This double star system was first observed in 1965 by Dutch-American self-proclaimed "Astronomical Curmudgeon," Willem Jacob Luyten. Luyten spent much of his astronomical career measuring the proper motions of stars at the University of Minnesota (Luyten, 1997). The coordinates of this star system are right ascension 18:16:17.02 , with a declination of +80° 27′ 44.9″. This system was first recorded as a physical double in 1965 with a separation (ρ) of 5.5″ and a position angle (θ) of 99 degrees. The most recent astrometric measurements were taken in 2015, which recorded a separation of 5.7″ and a position angle of 109° (Brown et al., 2018). The 2015 results were reported in 2018, by the Gaia spectroscopic survey (Gaia Collaboration, 2018). In total, this system has been observed five times since 1965. The primary star in this system has a magnitude of 10.96, the secondary star has a magnitude of 12.5. This research made a sixth measurement of the binary star system.

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Figure 1: LCO telescope at McDonald Observatory, Fort Davis, Texas

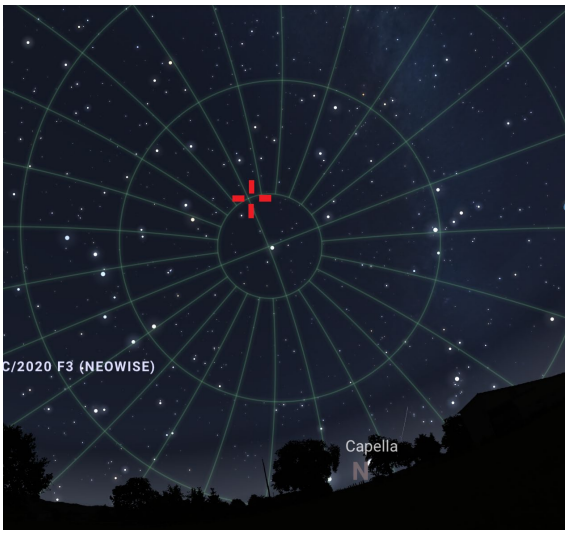

Figure 2: Location of binary star WDS 18166+8027 in the sky, shown by crosshairs. Credit: Stellarium.com

Methods

CCD images of WDS 18166+8027 were requested through the LCO telescope network (Figure 3). On July 14, 2020, from the McDonald observatory just outside Fort Davis, Texas in western Texas, a 0.4-meter telescope with an SBIG STL-6303 camera was used to capture 10 images of the system with a 1-second exposure. In addition, historical data published on the binary star system was requested from Dr. Brian Mason at the United States Naval Observatory. *AstroImageJ* software was then used to find the position angle and separation between the stars (Figure 3)(Collins et al., 2017).

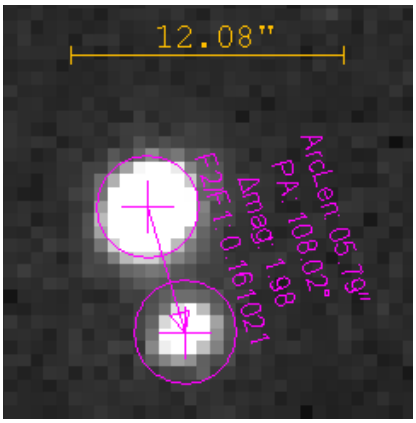

Figure 3: WDS 18166+8027 as viewed and measured in AstroImageJ

Results

Table 1 shows the average position angle and separation of the ten images of WDS 18166+8027. The average separation was 5.72 arcseconds and the average position angle was 107.79 degrees.

Table 1. Measurements of WDS 18166+8027 Over Multiple Images

Image Number	Position angle (°)	Separation (arcsec)	Delta Mag
1	107.64	5.72	2.00
2	108.36	5.61	1.99
3	107.69	5.80	1.93
4	107.83	5.67	1.87
5	107.21	5.90	1.99
6	108.00	5.79	1.98
7	107.04	5.75	1.93
8	107.77	5.63	1.92
9	107.80	5.72	1.94

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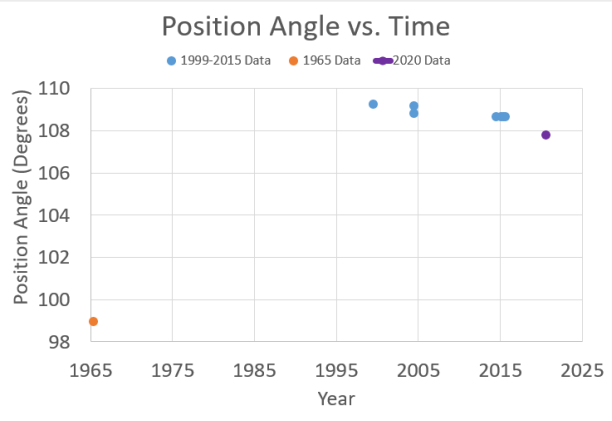
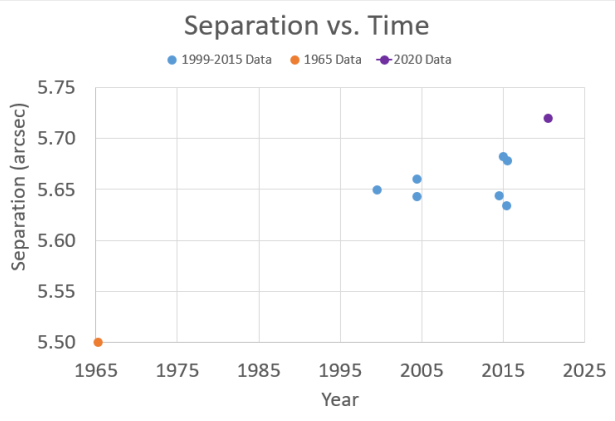
10	108.58	5.61	1.94
Mean	**107.79**	**5.72**	**1.95**
Std. Dev.	**0.46**	**0.09**	**0.04**
S.E.M.	**0.15**	**0.03**	**0.01**

Figures 4 and 5 show the change in the position angle and separation over time, based on all of the historical data plus the new data from 2020. Figures 6 and 7 show how the secondary star has moved in the sky over time according to the historical and new data.





Figures 4 and 5: These graphs depict historical data collected and stored in the WDS of binary system 18166+8027, showing the change in position angle over time (left) and separation over time (right). The new data point is added in purple and the original measurement from Luyten is highlighted in orange.

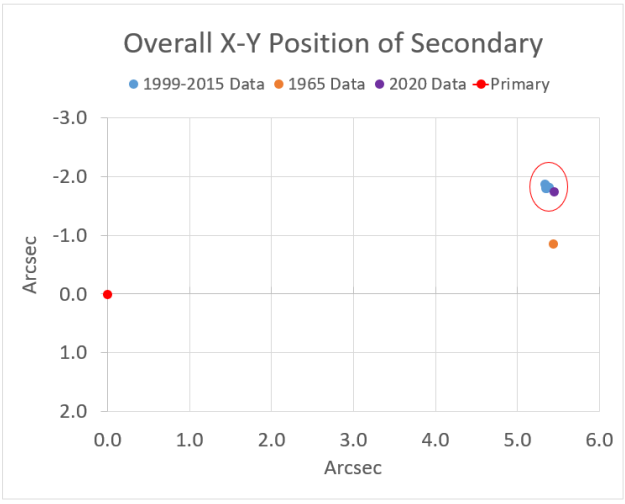


Figure 6. Historical data from the Washington Double Star Catalog of binary system 18166+8027, showing the sky position of the secondary star relating to the primary over time, with the earliest position in orange and the newest position is shown with a purple dot. The primary star is located at the origin in red for reference. The data used for Figure 8 on right are circled in red.

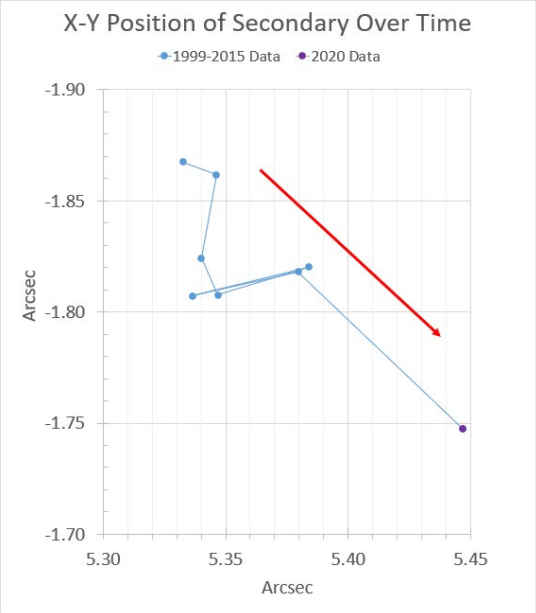


Figure 7. 1995 - 2020 data without Luyten's original measurement, showing the sky position of the secondary star over time, starting with the 1999 data at the top left blue dot. The red arrow indicates the overall direction of sequential measurements.

Discussion

Recent observations of WDS 18166+8027 have brought to light questions about the original measurement by Luyten. Figures 4 and 6 illustrate discrepancies in the 1965 data compared to the rest of the measurements. When including the 1965 data, Figure 5 shows the position angle increasing then decreasing over time, which is suspect. Figure 6 shows a linear trendline based on the 1999-2015 data predicting the separation and position angle change of the physical binary in an elliptical orbit, and the 1965 measurements do not align with the more recent data. Figure 7 shows how the 1999-2015 data indicates an overall direction of the secondary over time towards the 2020 measurement despite some scatter in the measurements, while the 1965 data does not follow this trend.

Parallax measurements from the Gaia survey of this pair indicate that they may not be close enough to each other to be gravitationally bound.

Table 2: Gaia Parallax data for WDS 18166+8027

	Primary	Secondary
Parallax (milli-arcsec)	18.33	19.92
Parallax Error (milli-arcsec)	0.10	0.03
Min. Distance to Earth (parsec)	54	50
Max. Distance to Earth (parsec)	55	50

These measurements indicate a 5 parsec (pc) difference between their distances from Earth, which translates to a minimum of a 5 pc separation between the two stars, which does not support the classification of this pair to be a gravitationally bound binary. The historical WDS data and the 2020 measurements do indicate a change of separation and position angle over time, so this pair may be an optical double with separate proper motions. Figures 4-7 could indicate a linear relative movement over time; however, there are not enough measurements of this pair to verify this assumption based on the collected data.

Conclusion

This study recorded a position angle of 107.79 +/- 0.46 degrees and a separation of 5.72 +/- 0.09 arcsecond for the double star system WDS 18166+8027 (LDS1884)s. Recent observations of this pair have brought into question the original measurement of this double star by Willem Luyten, and parallax measurements from the Gaia survey indicate that the stars may not be close enough to each other to be in a gravitationally bound orbit. With the low number of historical data points for WDS 18166+8027, further measurements are needed to confirm the validity of this system's classification as a physical binary.

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