Astrometric Measurements of WG 191

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Abstract: Our team performed astrometric measurements on the star WDS 16547-4053 using images acquired by the Las Cumbres Observatory (LCO). This was an effort to update the records of the star system, which had gone unreported for nearly 21 years, with only 5 prior reports from much earlier dates. From the images collected, we calculated average θ and ρ measurements of 174.4° and 8.84”. Our findings suggest a gravitational relationship between the two stars.

Introduction

The purpose was to identify and observe a double star system that had not been measured in over 20 years to better understand the possibility of a gravitational pairing. WDS 16547-4053 WG 191 (hereafter referred to as WG 191) had a total of 5 observations since its discovery in 1901. Located in the southern part of Scorpius, WG 191 resides in the star cluster NGC 6231.

This double star system’s most recent observation was in 1999, making it a neglected double star. The primary star is noted as a B2I/II star in the United States Naval Observatory logs. Upon reviewing historical measurements of WG 191, Figure 1, provided by the United States Naval Observatory (USNO), it was determined that the initial θ and ρ values are 175.5° and 8.7”. Later observations show changes to 174.4° and 8.84”. Table 1 outlines the historical measurements in θ and ρ of WG 191 where the range in data differing by 2° for θ and 0.3’’ for ρ.

WDS 16 54 44.83-40 52 51.2 WG 191		
Epoch	Theta θ	Rho ρ
1901.34	175.5°	8.7″
1903.64	176.4°	9.1″
1903.64	174.4°	8.8″
1987.348	174.8°	8.88″
1998.591	174.4°	8.87″
1999.36	174.6°	8.82″
2020.24	174.4°	8.84″

Table 1: All historical θ and ρ measurements are provided by USNO. The table shows very minimal changes throughout the past century, the range in data differing by 2° of θ and 0.3” of ρ.

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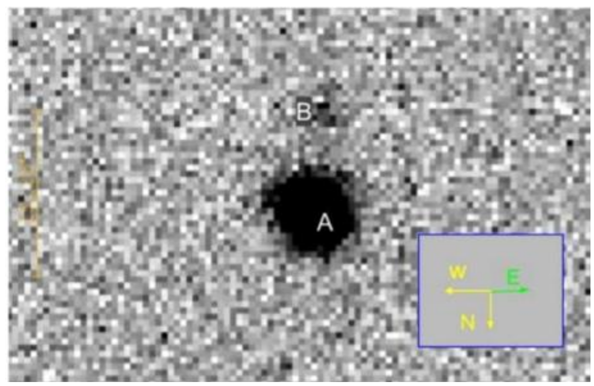

Figure 1: WG 191. The photo contains the LCO telescope image filter g. The telescope used was a 0.4 meter with a SBIG STL-6303 camera.

Methods and Materials

The images for WG 191 were taken through the Las Cumbres Observatory (LCO) system at Siding Spring, Australia. The telescope is at an elevation of 3,822 feet and is a 0.4-meter telescope with a SBIG STL-6303 camera. There were 9 filter options with a camera pixel scale of 0.571"/pixel (bin 1x1), and a field of view of 29'x19'.

A total of 56 photos were taken over three different nights through various filters, displayed on Table 2. Many of the photos were discarded because surrounding light pollution made the photos grainy and hard to measure. Selected photos were calibrated, and plate solved, through the Our Solar Siblings Pipeline (Fitzgerald 2018). AstroImageJ (AIJ) was used to measure θ and ρ in the best 15 images. Results were recorded and organized in a Microsoft Excel spreadsheet for calculations of the standard deviation, mean, and the deviation of the mean, Table 3.

Astrometric Measurements of WG 191

Filters	03-30-2020	03-31-2020	04-01-2020
G	—	3	—
Z	1	10	4
I	1	10	—
R	—	—	10
B	1	10	6

Table 2: Filters used across the 56 images taken over three days

WDS 16 54 44.83-40 52 51.2 WG 191								
Previous Measurement			Position Angle (θ) in 2020.24			Separation (ρ) in 2020.24		
Epoch	Mean θ	Mean ρ	Mean θ	Standard Deviation	Error of Mean	Mean ρ	Standard Deviation	Error of Mean
1999.36	174.6°	8.82″	174.4°	0.441°	0.0117°	8.84″	0.125″	0.032″

Table 3: 2020.24 θ and ρ results (middle and right) compared to previous averages in 1999.36 (left).

Results

The results are measured from 15 images in 2020.238 and 2020.251, averaged to an epoch of 2020.24. Table 3 compares the measurements most recently preceding ours, 1999.36, to our own results, listed respectively from left to right.

Discussion

The A star has a parallax of -0.04637 +/- 0.626 milli-arcseconds while the B star has a parallax of 0.41 +/- 0.0655 milli-arcseconds. As shown in Figure 4, WG 191 is viewed through a scattered cluster, making parallax values harder to ascertain. Due to the relative energy of the nearby stars, the uncertainty is represented with a negative sign (Lee 1943), and because of this uncertainty in the A star's parallax, we cannot use it as a way of calculating a definitive distance between the A and B star. However, it is possible to calculate the closest possible distance between the stars using the B star's parallax.

From this research, the separation of WG 191's A and B stars is 8.8 arcseconds in epoch 2020.24. The first observation in 1901 recorded a separation of 8.7 arcseconds while our observations, alongside the last

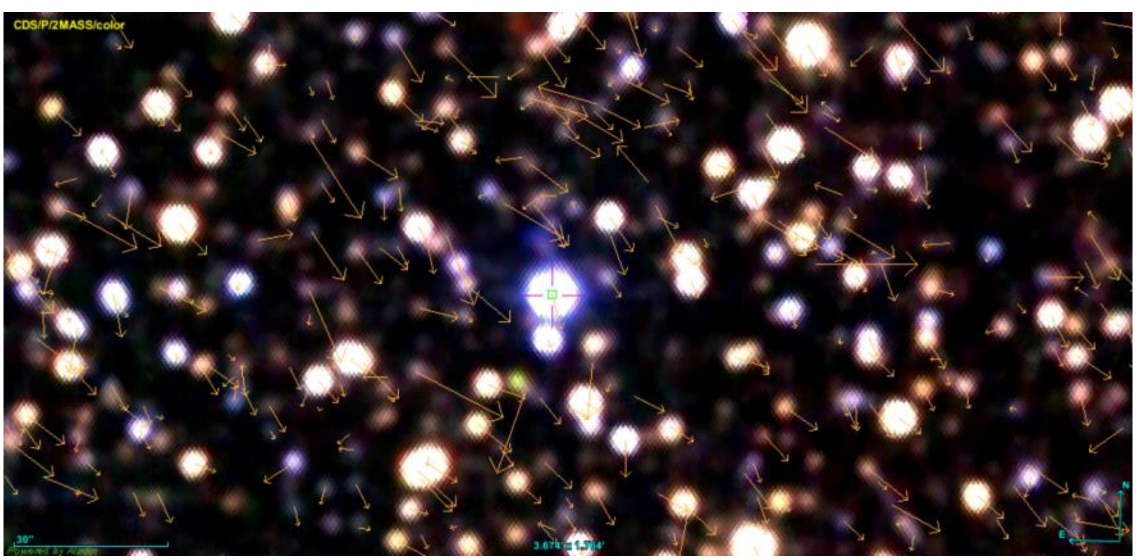

Figure 4: This Aladin 10 image of WG 191 depicts proper motion measurements. The position angle is 164.97 degrees. The arc length of the set is 1.272862 minutes. The cardinal directions have east facing to the left and north facing upwards.

Astrometric Measurements of WG 191

observation in 1999, assumed a separation of 8.8 arcseconds. The current separation is 8.839 arcseconds when measured with AIJ software.

Assuming the low possibility that both parallaxes are identical, we can use trigonometry to find the current closest distance. First, the known parallax was converted into parsecs using the equation $\frac{1}{(0.41 + 0.0655) \times 10^{-3}}$ (with 0.41 as the parallax and 0.0655 as the parallax error) to find that the secondary star is about 2,103 parsecs away. After the conversion, we used the equation D= $8.8 \frac{2103}{206265}$ (8.8 is the separation in arcseconds) to find the current closest distance between the stars; it rounds to 0.0897 parsecs, which when put into AU reveals that the two stars are a minimum 18,466.4 AU away from each other.

As seen in Figures 5 and 6, the previous and current measurements of WG 191 don't depict any significant change in θ and ρ that would indicate an orbit. That can be explained by the separation found in the current closest distance calculation. In assuming that the parallax is identical for both stars, the distance between the two would be about 18,466.4 AU. After using the research tools provided by Boyce Research Initiatives and Education Foundation, we found that those conditions would allow for a wide-to-fragile orbit radius, which has a maximum radius of 25,000 AU and would take upwards of 500,000 years to complete its orbit. Because of this, it is reasonable that the recorded measurements taken over 119 years show virtually no change because it is just a fraction of the massive orbit, if one existed.

Table 4 shows that the proper motion data of WG 191's A and B stars have similar proper motions and little variation between the two data sources- WDS and GAIA. Using this data, the probability of the system being gravitationally bound can be determined with the Harshaw Proper Motion Statistic (Harshaw 2017). This statistic uses proper motion data to determine whether a pair of stars are binary; the closer the number is to 0, the higher the possibility that the two stars are gravitationally bound. For WG 191, the Harshaw Statistic is 0.212366, showing that the difference in proper motion vectors are around 0.21. As an independent factor, our value is ambiguous, however it leans towards binary.

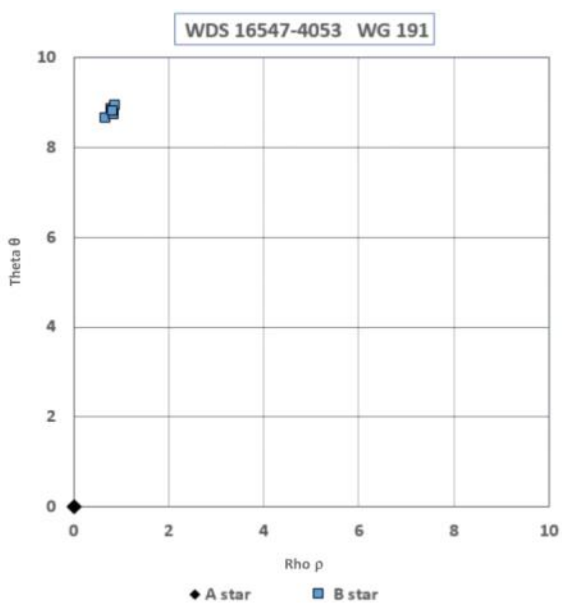

Figure 5: shows the θ and ρ of WG 191

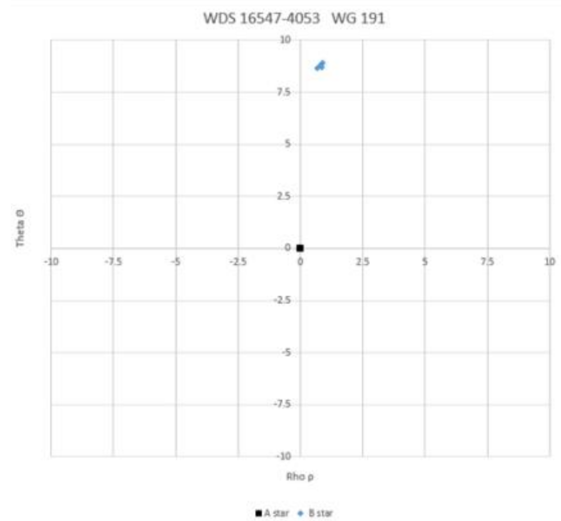

Figure 6: provides the same data points from Figure 5 but shows the entirety of WD 191's rotation

Conclusion

Our evidence shows that the gravitational nature of this system is inconclusive. Due to the stars inhabiting a large cluster, the specific system is very difficult to measure. There is no data related to radial velocity on either star, and the Gaia database lists the primary parallax as a negative number, which is physically impossible and therefore not comparable with the secondary parallax. With this lack of data definitive conclusion as to the gravitational nature is difficult. However, the measurements currently available reveal that it is possible for the system to be binary. The closest current distance supports this possibility by showing that with an 8.84'' angular separation and a 0.41 secondary parallax, it is possible for the two stars to be separated by about 18,466.4 AU, allowing a gravitational pull. The proper motion is similar throughout both stars as well, with a Harshaw Statistic of 0.21 slightly leaning towards the possibility of being binary. Additionally, other stars may impact the gravitational pull of WG 191 because the system resides in a dense star cluster.

Astrometric Measurements of WG 191

WDS Proper Motion			GAIA Proper Motion			Proper Motion Errors		
	RA	Dec		RA	Dec		RA	Dec
A Star	-2	-7	A Star	-1.695	-6.692	A Star	0.92	0.794
B Star	-1	-1	B Star	-0.546	-1.359	B Star	0.083	0.065

Table 4 displays comparative data from the WDS, derived from the USNO (left), GAIA Archives (middle), and the error of means (right).

Acknowledgements

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This work has made use of data from the European Space Agency 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).

This work makes use of observations from the LCOGT network.

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