An Astrometric Measurement of WDS 16476-4708 AB and AC

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Abstract: Over three months, images were taken and processed to observe WDS 16476-4708 AB and AC. This research was conducted to contribute to the historical narrative and attempt to classify the two components as either visual doubles or a gravitationally bound pairs. Using telescopes from the Las Cumbres Observatory network, images were taken using varying filters and exposure times. The data for the AB component showed a mean separation of 4.14" and a mean position angle of 161.5º. The AC component was measured with a mean separation of 28.6" and a mean position angle of 251.4º. After analyzing the data, it was determined that, although furhter measurements would provide a stronger conclusion, it is too soon to determine the system's gravitational nature.

Introduction

WDS 16476-4708 AB and AC, Figure 1, were chosen due to a few aspects of the star system that peaked the group's interest: a gap in historical measurement and a unique opportunity to contribute to the historical narrative of the star system. Although no movement had been previously observed, the long period since the last measurement meant that observations of the system may provide useful data. A total of six observations were recorded for the AB component of the system between 1902 and 1999. Of these observations, a total change in separation of 0.3" and a change in the position angle of 2° were reported. The AC component of the star was measured a total of three times between 1987 and 1989 with a total change in separation of 0.2" and a change in position angle of 2°. All stars in the system are blue-white in spectral type.

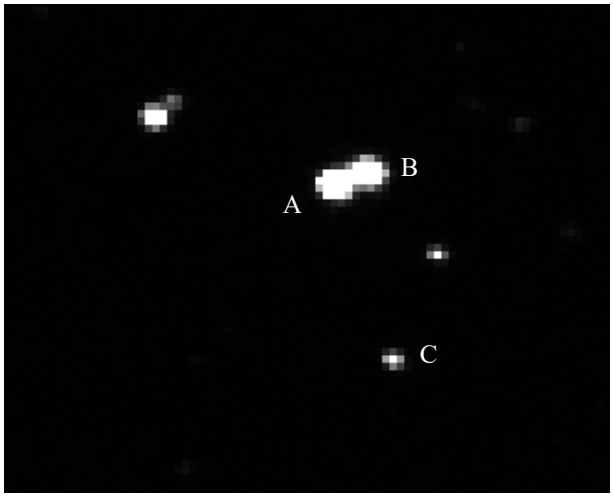

Figure 1. WDS 16476-4708 AB and AC pairs measured with a red filter, April 7, 2018, Julian Date 2458216.

Materials and Methods

The observer portal through the Las Cumbres Observatory (LCO) was used to image the AB and AC components of this system. On April 7, 2018, a Julian date of 2458216, 56 images were collected using the 0.4-meter telescopes with SBIG CCD camera based in Sutherland, South Africa and Siding Spring, Australia. The telescope operated with 2x2 binning fiving with an effective resolution of 1.14" per pixel. The model number of the telescope used was 0M-SCICAM-SBIG. Roughly three quarters of the ordered images returned successfully while the remaining were unsuccessful due to the scheduled window closing. The filters used were the PanSTARRS- W and Z filters, the SLOAN r-band, and luminance. The SLOAN r-band filter was used to even out the brightness of the stars due to the difference in magnitude of 3.4 between the A and C stars. Additionally, the PanSTARRS- Z was used to brighten the C star and make it more visible. PanSTARRS- W was used to highlight the C component of the system.

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Image processing was through the Our Solar Siblings (OSS) pipeline (Fitzgerald 2018) to ensure image quality through a process of cleaning and processing, photometry, calibration, and aligning each image with World Coordinate Systems (WCS) positions. The software program, Mira Pro, was used to analyze the images received and take distance and angle measurements. Each measurement was made independently by two team members to reduce the possibility of measurement error. Once each member recorded a value for the separation and angle between the stars, the data was compared to ensure accuracy. Some of the images were only useful in determining the position of the AC component and not the AB component. For these images, only the AC component was considered and used for statistical calculations.

Results

A total of eight measurements for the separation and angle of the AB component were taken, as shown in Table 1. The separation and position angle for the AC component was measured a total of twenty-three times, shown in Table 2. The mean, standard deviation, and standard deviation of the mean for the AB and AC pairs are outlined in Table 3. All the images were taken on April 7th, 2018, or Julian Date 2458216, at Siding Spring Observatory in NSW, Australia.

Discussion

For the AB component of the star system, there were a total of six measurements between 1902 and 1999, Figure 2. As represented by the graph of the historical data, using an Excel tool developed by Richard Harshaw, these measurements present a linear pattern. Table 4 shows the year and data from each measurement.

For the AC component of the star system, a total of three measurements were taken between 1987.36 and 1999.38. The historical data, Figure 3, shows a relatively linear distribution apart from the 1987.36 measurement. This datum is not enough to conlude anything concrete about the movement of the system. Further measurements are necessary to provide an accurate analysis of the system.s gravitational nature.

Upon analysis of the measurements for the AB component of the star, it became clear that the combination of few usable images and a large standard deviation meant that the data needed to be further investigated. The mean for these initial measurements gave a separation of 4.14" and a position angle of 161.51°. The images were originally measured with a three-pixel centroid, so all the images were re-analyzed using a two-pixel centroid. This produced measurements that were all roughly an arc second more than the previous

Table 1. Individual measurements for AB pair taken April 7th, 2018, JD24582216.

Image exposure time	Filter	AB angle	AB separation
3.281 s	SDSS- r (red)	162.49°	3.79"
1.282 s	luminance (clear)	162.19°	3.97"
1.283 s	SDSS- r (red)	160.96°	4.59"
3.282 s	SDSS- r (red)	161.31°	3.95"
6.284 s	PanSTARRS- W	160.57°	4.75"
6.292 s	PanSTARRS- W	160.83°	4.70"
8.28 s	PanSTARRS- Z	161.67°	3.69"
14.291 s	PanSTARRS- Z	162.06°	3.69"
Mean	-	161.51°	4.14"

Table 2. Individual measurements for AC pair taken April 7, 2018., JD 2458216.

Image exposure time	Filter	AC angle	AC separation
3.281 s	SDSS- r (red)	251.26°	28.60"
1.282 s	luminance (clear)	251.33°	28.65"
1.284 s	luminance (clear)	253.16°	28.88"
4.281 s	luminance (clear)	251.36°	28.53"
4.282 s	luminance (clear)	252.22°	28.42"
9.281 s	luminance (clear)	251.12°	28.45"
9.291 s	luminance (clear)	251.75°	28.57"
1.283 s	SDSS- r (red)	250.69°	29.07"
3.282 s	SDSS- r (red)	251.96°	28.58"
6.293 s	SDSS- r (red)	251.12°	28.60"
6.296 s	SDSS- r (red)	250.71°	28.59"
1.285 s	PanSTARRS- W	251.29°	28.39"
1.293 s	PanSTARRS- W	251.90°	28.54"
3.284 s	PanSTARRS- W	251.79°	28.70"
3.291 s	PanSTARRS- W	250.90°	28.76"
6.284 s	PanSTARRS- W	250.80°	28.55"
6.292 s	PanSTARRS- W	250.87°	28.43"
8.28 s	PanSTARRS- Z	251.86°	28.48"
8.281 s	PanSTARRS- Z	250.72°	28.59"
14.285 s	PanSTARRS- Z	251.65°	28.59"
14.291 s	PanSTARRS- Z	251.70°	28.70"
20.29 s	PanSTARRS- Z	250.78°	28.50"
20.288 s	PanSTARRS- Z	252.12°	28.65"
Avg. Stack 60.0 s	luminance (clear)	251.39°	28.54"
Mean	-	251.44°	28.60"

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Table 3. Results – Mean, Standard Deviation, and Deviation of the Mean for the AB and AC Pairs. See "Discussion" for explanation of AB measurements.

Results	Epoch	AB		AC	
	2018.27	Theta	Rho	Theta	Rho
Mean		161.5°	4.13"	251.4°	28.6"
Standard Deviation		0.6°	0.5"	0.6°	0.2"
Standard Deviation of the Mean		0.2°	0.2"	0.1°	0.0"

Table 4. Historical measurements of WDS 16476-4708 AB

Epoch	Position Angle	Separation
1902.54	163.0°	4.755"
1903.92	161.1°	5.0"
1904.57	161.2°	5.131"
1904.65	159.6°	5.429"
1987.355	159.78°	5.41"
1998.54	159.8°	5.419"
1999.38	160.6°	5.10"
2018.27	*161.5°*	*4.14"*

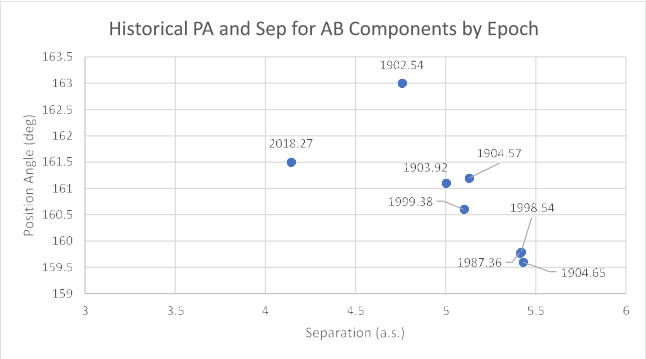

Figure 2. Historical Plot of WDS 16476-4708 AB

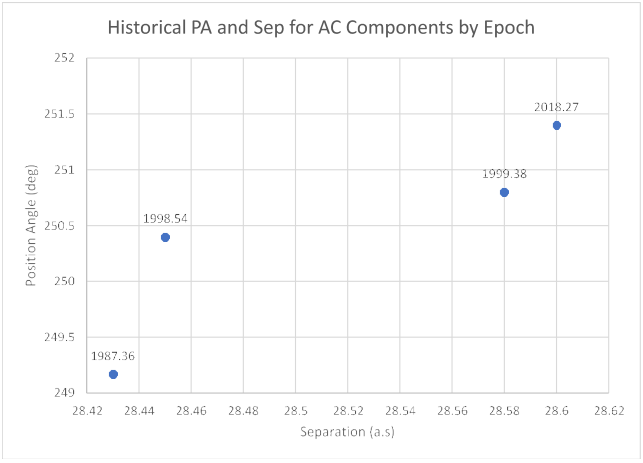

Figure 3 Historical Plot of WDS 16476-4708 AC.

Table 5. Historical measurements for WDS 16476-4708 AC

Epoch	Position Angle	Separation
1987.355	249.17°	28.43"
1998.54	250.40°	28.45"
1999.38	250.80°	28.58"
2018.27	251.40°	28.60"

measurements. Next, data from the Gaia satellite was compared to the measurements to determine a more accurate answer. The Gaia satellite data reported a separation of 4.858" and a position angle of 161.0°, close to what we had reported. It was decided that the Gaia satellite measurement was likely the most accurate and, since our data was so close, we reported our initial measurement. Since none of these problems were present in the measurements of the AC component, it is likely that the small distance between the two stars made it difficult to measure on the available equipment.

Conclusion

Measurements were successfully taken for WDS 16476-4708 AB and AC. The AB component showed a slow but steady increase in separation until this year's measurement, which decreased by roughly an arcsecond. The position angle also steadily decreased but increased in both the 1999 measurement and our measurement. The AC component of the system has seen an increase in separation although it was much smaller than the change observed in the AB component. The position angle for AC has also steadily increased. It is difficult to conclude anything about the gravitational nature of the system with such little data, but future measurements would help identify the possibility of an orbital path.

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