CCD Measurements of AB and AC Components of WDS 20023+6438

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Abstract: Measurements of the position angles and separation are collected and documented for the triple star system WDS 20023+6438 with components of STTA200AB and STTA200AC. Our observations of the AB component are consistent with the motion trend established by previous observations. The AC component showed no significant deviation in position from prior observations. Results from the Gaia database for this system of stars were also considered, suggesting that neither component is gravitationally bound and that the AC component may be a common proper motion pair.

Introduction

Studying the position and orbits of multiple star systems yields scientifically useful information. The masses of stars can be calculated by using information on orbital pairs, providing insight into stellar life cycles. Before the nature of an orbital pair can be determined and used for scientific study, measurements of the separation (ρ) and angle (θ) must be conducted over several years. This process aids in determining if stars are gravitationally bound and is therefore useful for further study. Our goal was to provide additional information regarding the separation and position angle for the system WDS 20023+6438 for further evaluation and to aid in determining if the system is gravitationally bound.

WDS 20023+6438 is a triple star system comprised of a central star and the two component stars STTA200AB and STTA200AC. It is unknown if both the components of this system are gravitationally bound to the same central star, composing a ternary system, so further observation was needed. This star system was first observed in 1875. Before our current work, the most recent observation occurred in 2013. This system was chosen for its numerous prior observations, the long period over which it has been observed, and because it was within the capability of the Great Basin Observatory (GBO) telescope. This research was conducted at Southern Utah University by a team of interdisciplinary students including students pursuing degrees in philosophy, chemistry, criminal justice, biology, computer science, human nutrition, and applied mathematics.

Methods

This research was conducted using the robotic telescope at the Great Basin Observatory in Great Basin National Park, as shown in Figure 1. This is the first research grade telescope in a national park. The telescope is managed by the Great Basin National Park Foundation in collaboration with four university partners: Southern Utah University, University of Nevada-Reno, Western Nevada College, and Concordia University. The GBO is equipped with a PlaneWave 0.7-m CDK 700 telescope (Great Basin Observatory, 2016). The telescope has an aperture of 27 inches and a focal ratio of f/6.5. The SBIG STX 16803 camera also has a field of view of 27x27 arcminutes and a plate scale of 0.4 arcsec per pixel. This telescope is equipped with sixteen filters housed in two nested Finger Lakes filter wheels: LRGB, Ha, OIII, SII, BVRI, griz, and a diffraction grating.

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Figure 1. The GBO Planewave CDK 700 telescope at the Great Basin Observatory located at Great Basin National park in Nevada. Photo by project manager Paul Gardner of Observatory Systems.

WDS 20023+6438 was observed on the night of March 7th, 2018. The primary star's brightness was significantly greater than the companion stars. This presented the necessity to properly expose the companion stars without over exposing the primary star. 60 second exposures we're made to ensure that no saturated pixels existed for the primary star and had a maximum pixel count around 45K. We also took 30 second exposures to see if measurements changed when the companion stars were slightly underexposed. There were 10 images collected with an exposure time of 60 seconds and 10 images that were collected with an exposure time of 30 seconds, giving a total of 20 images. All images were taken with a V filter. A sample image is shown in Figure 2. We did not observe a significant difference in measurements between our 30 second and 60 second exposures, so the measurements were combined in the results reported in the following sections.

Each image was calibrated by applying dark, flat and bias frames using the software AstroImageJ (Collins et al. 2017). Calibrating the images removes artifacts and noise that are inherent to the electronics and optics of our telescope system. The frames were also plate solved through AstroImageJ. Plate solving converts the X and Y coordinates of the images to the right ascension and declination in the World Coordinate System. After calibrating and plate solving, the position angle (θ) and separation value (ρ) were measured through AstroImageJ. The centroid of the star was used to improve the accuracy of these measurements.

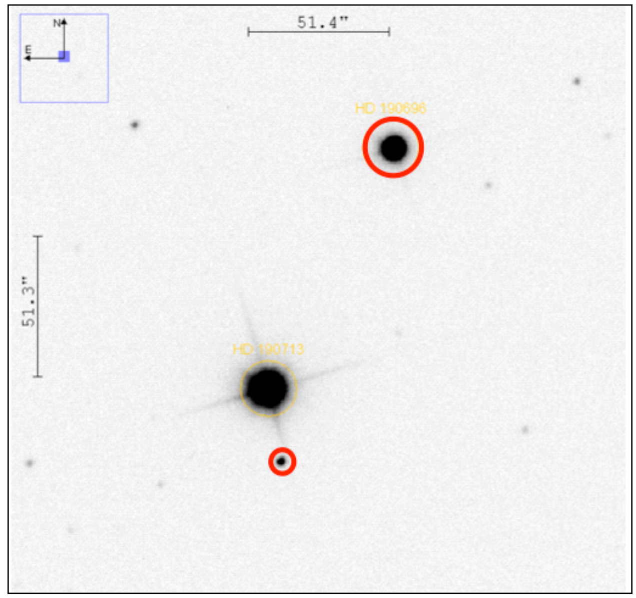

Figure 2. Image depicting components of WDS 20023+6438. Plate Scale: 0.4 arcsec/pixel. The A component star is the bright, unmarked star near the middle. The two component stars are marked with red circles. The B component is the upper star and the C component is the lower star.

Results

The mean, standard deviation, and standard error for each component star was calculated. Table 1 displays these statistics comprised from the 20 V filter images for each respective component.

Table 1: Data and observations from our images. Standard deviation, standard error, position angle (Θ) and separation (□).

WDS No.	ID	Nights	Date	Observations		Θ (°)	□ (")
20023+6438	STTA200AB	1	2018.18	20	Mean	332.372	98.939″
					Std. Dev.	0.04503	0.014202″
					Std. Error	0.00712	0.00225″
20023+6438	STTA200AC	1	2018.18	20	Mean	190.197	26.967″
					Std. Dev.	0.08869	0.2564″
					Std. Error	0.01402	0.0405″

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Table 2: Select historical data points for STTA200AB, with our measurement highlighted in yellow.

Epoch	θ (°)	ρ (")	Epoch	θ (°)	ρ (")
1875.15	338.2	96.66	1929.66	335.7	97.48
1883	337.8	96.8	1956.71	334.6	97.898
1894.78	337.4	97.226	1958.6	334.5	97.995
1900.4	337.1	97.121	1985.6	333.5	98.634
1905.82	336.6	96.84	1986.78	333.5	99.02
1909.82	336.9	97.28	1987.5	333.5	98.545
1912.22	336.5	97.34	1990.96	333.2	98.663
1912.71	336.8	96.57	1991.25	333.3	98.556
1913.68	336.7	96.9	1991.73	333.2	98.57
1913.68	336.5	96.969	1994.02	334.2	97.7
1913.79	336.6	98.1	1999.42	333	98.63
1914.75	336.3	97.208	2003.701	332.9	99.03
1923.84	336.1	98.24	2018.18	332.4	98.94

Discussion

Table 2 shows the historical data of the AB component for STTA200AB. The values cover a time period from 1875 to 2018 with a total of 30 measurements during that period. The data values from 1991, 1999, and 2010 were not included because they do not have data values for θ and ρ. The values indicate a constant decrease in the value of θ and ρ value that fluctuates over time. Our findings agree with this trend, as shown in Figure 3.

Table 3: Historical Data for STTA200AC, with our measurements highlighted in yellow.

Epoch	θ (°)	ρ (")
1905.75	191.7	26.7
1960.7	190.7	32.2
1999.42	190.1	26.9
1999.42	190.1	26.9
1999.42	190.1	26.9
2000	190.2	26.9
2003.701	190.4	26.43
2013.521	189.87	26.62
2018.18	190.20	26.96

Table 3 contains the historical data for the observations of the AC component. From these 9 observations we can see that the position angle is reasonably constant. Our position angle is within 0.1% of the mean of the previous measurements. Ignoring the outlier from 1960, the separation value is in good agreement with historical measurements.

Figure 3 is a plot of all gathered data for the star system, with our results represented in red. The AB component appears to follow the trend of past data, supporting the historical path observed. Our measurement of the AC component does not show significant change from previous values. We have not distinguished any gravitational interaction with the primary star from the addition of our measurements.

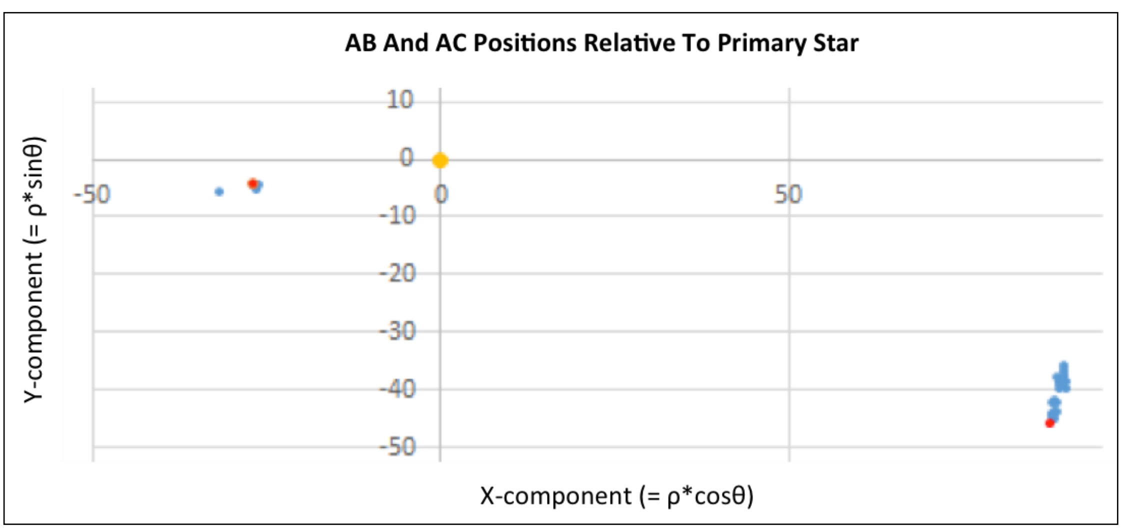

Figure 3. This graph plots our observed data points for the AC and AB components (shown in red) along with the available historical data points (shown in blue). The primary star is located at the origin (in yellow). The AB component measurements appear in the right side of the graph, the AC component in the left side.

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Table 4: Data obtained from ESA's Gaia astronomy satellite (Gaia Collaboration et al. 2018). This given data was used to help determine if these are gravitationally bound, specifically the distance.

Components	Parallax [milliarcsec]	Distance [lightyear]	Proper Motion RA [milliarcsec /year]	Proper Motion DE [milliarcsec /year]
A	8.60 ± 0.03	379 ± 1	42.08 ± 0.07	11.84 ± 0.06
B	3.81 ± 0.03	855 ± 5	-9.35 ± 0.06	3.76 ± 0.06
C	8.73 ± 0.02	373 ± 1	42.07 ± 0.05	11.02 ± 0.05

To extend our examination of these stars, in addition to our position measurements, we used the Gaia database (Gaia Collaboration et al. 2016, 2018). We searched the Gaia database and found parallax and proper motion measurements for all components in this system. These measurements are shown in Table 4. The measurements show there is a significant distance of 476 l.y. between the A and B component stars and that their proper motions are noticeably different. As a result, the AB component of this system should be considered an optical double and not gravitationally bound. Components A and C are relatively close to each other with about 4 l.y. of separation and have similar proper motions. Over 100 years of observational measurements has not provided direct evidence indicating that they are physically associated; although, a likely possibility is that the AC component is a common proper motion pair.

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References

Collins, K. A., Kielkopf, J. F., Stassun, K. G., & Hessman, F. V., 2017, *The Astronomical Journal,* **153** (2), 77.

Great Basin Observatory, 2016, retrieved June 04, 2018, from http://planewave.com/great-basin-observatory/

Washington Double Star Catalog, 2012, retrieved March 30, 2018, from http://ad.usno.navy.mil/wds/

Gaia Collaboration: T. Prusti, J. H. J. de Bruijne, A. G. A. Brown, A. Vallenari, C. Babusiaux, C. A. L. Bailer-Jones, U. Bastian, M. Biermann, D. W. Evans, et al., 2016b, "The Gaia mission", *A & A,* **595**, pp. A1.

Gaia Collaboration: A.G.A Brown, A. Vallenari, T. Prusti, J.H.J. de Bruijne, Babusiaux, C.A.L. Bailer-Jones et al., 2018, "Gaia Data Release 2. Summary of the contents and survey properties", *A & A,* Accepted for publication.