# CCD Measurements of AB and AC Components of WDS 20420+2452

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**Abstract**: Measurements of position angles and separation are obtained from CCD images and recorded for the triple star system WDS 20420+2452 with components POU4886AB and POU4887AC. Our measurements suggest that component B is not gravitationally bound to the primary component. No orbital trend is observed for POU4887AC, but further observations may indicate an orbital trend.

## Introduction

Multiple star systems are scientifically interesting for several reasons. Orbital pairs can be used to measure the masses of the component stars, which is useful for developing a greater understanding of the stellar life cycle. Observations of the separation (ρ) and position angle (θ) of the system are conducted over the course of many years to gather sufficient data to establish or rule out an orbital relationship. Identifying whether the stars are gravitationally bound is the first step towards determining the mass of the component stars. The goal of our project was to provide an additional measurement of separation and position angle for the system WDS 20420+2452 in order to help determine if the components of this system are gravitationally bound.

WDS 20420+2452 is a triple star system consisting of components POU4886AB and POU4887AC, and is found in the constellation Vulpecula. It is unknown whether this system is a ternary system, where both components are gravitationally bound to the same central star. This star system was first observed in 1899 and most recently observed in 2008. WDS 20420+2452 was selected due to the scarcity of previous observations and based on the capabilities of the Great Basin Observatory (GBO) Planewave CDK 700 telescope. Triple star systems can be examined in the same manner as double star or binary star systems. This research was conducted by a group of interdisciplinary students interested in astronomy at Southern Utah University.

*Figure 1. Great Basin Observatory and the control room, housing servers, weather station, and control computers.*

Our team includes students pursuing Criminal Justice, Physical Science Education, Rotor Wing Aviation, and Biology.

## Methods

This research was conducted using the robotic telescope seen in Figures 1 and 2 located at Great Basin Observatory in Great Basin National Park, Nevada. This observatory is the first and only research grade telescope in a national park, and is managed by the Great Basin National Park and the Great Basin National

Park Foundation, in collaboration with four educational partners: University of Nevada-Reno, Western Nevada College, Southern Utah University, and Concordia University. The GBO has an aperture of 27 inches and a focal ratio of f/6.5, while the SBIG STX 16803 camera has a field of view of 27X27 arcminutes and a plate scale of 0.4 arcsec per pixel. The telescope is equipped with sixteen filters housed in two nested Finger Lakes filter wheels: LRGB, Ha, OIII, SII, BVRI, griz, and a diffraction grating.

WDS 20420+2452 was observed remotely on the night of October 25, 2017. We collected 26 images of our target, with an exposure time of 90 seconds each. A total of 23 photos were taken with a visible, or green, filter (V), with the remaining three photos taken with a red filter (R). Each image was then calibrated by applying dark, flat, and bias frames using AstroImageJ (Collins et al. 2017). This calibration removes artifacts and noise that are inherent and unique to the electronics and optics of our telescope system. After the frames were calibrated, they were plate solved using Astrometry.net. Plate solving converted the X and Y coordinates of the images to right ascension and declination in the World Coordinate System. This step is necessary to allow for accurate measurements of ρ and θ.

With calibration completed, we then used AstroImageJ to measure the position angle and separation for the components of our system, shown in Figure 3. To improve the accuracy of these measurements, they were performed using the centroid of the stars. Before using the centroids for measurement, we ensured no saturated pixels existed. The separation and position angle measurements for each image were then exported to Excel, where the determination of the mean, standard deviation, and standard error for both components was made.

Measurements for each component of the system are found in Table 1. The mean, standard deviations, and standard errors from our 26 images are shown for both components.

## Discussion

WDS 20420+2452 has 4 observations listed in the Washington Double Star Catalog, with the first observation made in 1899 and the most recent being in 2008 (Hartkopf 2013). Our measurements are very similar to the most recent values gathered in 2008, as shown in Figure 4. Both the A and B stars have moved very little over the past century, making it difficult to determine their true orbit. However, it would appear that the B component is not gravitationally bound to the primary star. Additional observations over a larger timespan will be necessary to determine the orbits of these stars.

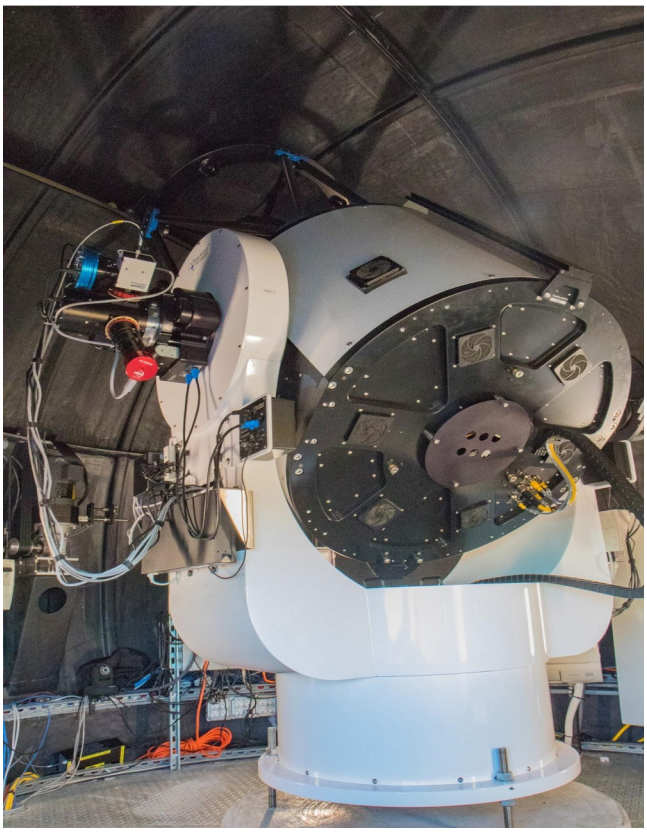

*Figure 2. GBO Planewave CDK 700 telescope. The filter wheels and camera can be seen attached to the left side of the telescope. The dome is continuously air conditioned so it is readily available and at ambient temperature for nighttime observations.*

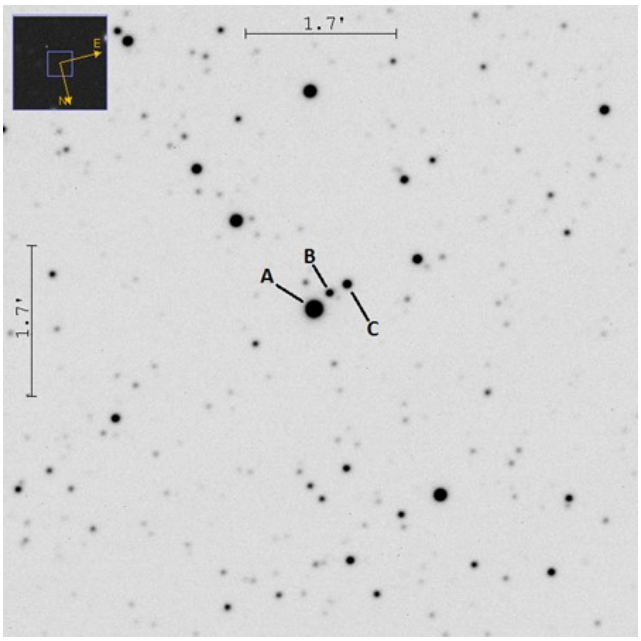


*Figure 3. A, B, and C components of WDS 20420+2452. Plate Scale: 0.4 arcsec/pixel.*

# CCD Measurements of AB and AC Components of WDS 20420+2452

*Table 1: Observations and data collected from our images. Position angle (θ), separation (ρ), standard deviation, and standard error are shown.*

| WDS No. | ID | Nights | Date | Observations | | θ | ρ |
|---|---|---|---|---|---|---|---|
| 20420+2452 | POU4886AB | 1 | 2017.82 | 26 | Mean | 121.998° | 15.52" |
| | | | | | Std. Dev. | 0.0752° | 0.021" |
| | | | | | Std. Error | 0.015° | 0.004" |
| 20420+2452 | POU4887AC | 1 | 2017.82 | 26 | | θ | ρ |
| | | | | | Mean | 112.86° | 28.68" |
| | | | | | Std. Dev. | 0.025° | 0.0133" |
| | | | | | Std. Error | 0.005° | 0.003" |

*Table 2: Historical data for POU4886AB.*

| Epoch | θ | Rho |
|---|---|---|
| 1899.67 | 118.8° | 15.5" |
| 2000.34 | 120.9° | 15.45" |
| 2001.76 | 121.6° | 15.48" |
| 2008.852 | 122.55° | 15.7" |
| 2017.820 | 121.998° | 15.52" |

## POU4886

Table 2 shows the historical measurements of the AB component. These measurements were recorded by Berko (2010), Pourteau (1933), 2MASS (2003), and Hartkopf et al. (2013). Figure 4 compares our measurements of the B component to the data in Table 2. We see an increase in θ although ρ remains unchanged, which suggests that the B component is not paired to the primary star. More observations are needed to determine whether this pair is gravitationally bound.

The average ρ for the AB component is 15.53 arcseconds. The percent difference is 1.1% for the high value and 0.51% for the low value, indicating no significant change in separation between these stars over the past century. The average θ for the AB component was calculated as 121.17" with a difference of 1.14% for the high and 1.96% for the low value. This is somewhat higher than seen for ρ.

## POU4887AC

Table 3 shows historical data for the C component. Figure 4 also compares our measurement of the C component with the historical data in Table 3. The AC pair has not demonstrated any significant change in θ or ρ. The average ρ for the AC component is 28.63″ with a difference of 1.61% for the high and 1.73% for the low value, showing a very small difference among all obser-

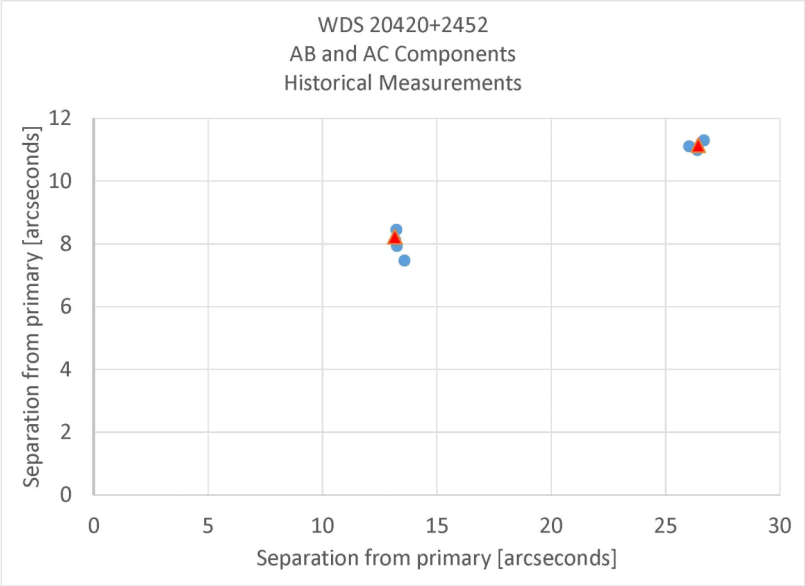


*Figure 4. This graph depicts our measurements (red triangles) of both B and C components, together with historical measurements (blue circles). All measurements are in arcseconds, and the primary star is located at the origin.*

*Table 3: Historical data for POU4887AC.*

| Epoch | Theta | Rho |
|---|---|---|
| 1899.67 | 113.1 | 28.3 |
| 2000.34 | 112.6 | 28.59 |
| 2001.76 | 112.7 | 28.631 |
| 2008.852 | 112.94 | 28.97 |
| 2017.820 | 112.86 | 28.68 |

vations. For the AC pair, the average measurement for θ is 112.84″ with a difference of 0.23% for the high and 0.213% for the low. As a result, we are not able to make any assertions regarding the relationship between the A and C components of this triple star system Future observations are needed to yield a noticeable trend.

Figure 5 shows a magnified view of the motion of the B component around the C component. The motion of B appears curved which suggests a potential orbit around the C component. Further observations will be necessary to determine whether this is a true orbit. The proper motions of these two stars should also be examined to determine if this is a common proper motion pair.

## Acknowledgements

This paper is the result of research performed by undergraduates at Southern Utah University in collaboration with the Department of Physical Science and the Great Basin Observatory partnership. We owe thanks to those who maintain and allowed us to work with the Great Basin Observatory. We would also like to thank Russell Genet for the materials and support he has contributed to this effort. This research has made use of Stellarium, AstroImageJ, Astrometry.net, and the Washington Double Star Catalog maintained at the U.S. Naval Observatory. The operators at the WDS Catalog were a great help in providing information from prior observations.

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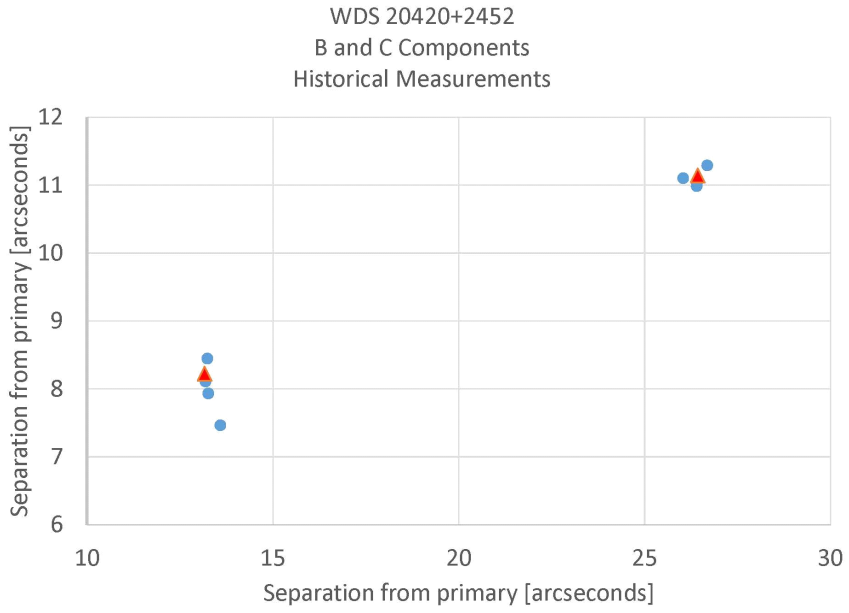


*Figure 5: This graph shows a magnified view of the data presented in Figure 4. The motion of the B component (left) appears to curve away from the primary (not shown, but located at (0,0)), suggesting that they are not bound. This motion also suggests that the B component may be gravitationally bound to C.*