# Astrometric Measurements of WDS 02578+4431 and WDS 05458+3149

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**Abstract**: We report CCD astrometric measurements of the double star systems WDS 02578+4431 STF 328AB and WDS 05458+3149 BKO 310AB using the iTelescope network. The measurements made herein were as follows: STF 328AB: position angle = 306.08 ± 0.25° (±1σ), separation = 14.65 ± 0.06" (±1σ); BKO 310: position angle = 259.11 ± 0.18° (±1σ), separation = 14.84 ± 0.04" (±1σ). These measurements, combined with analysis of historical data, support the rectilinear solution (Mason and Hartkopf 2015) for AB component of WDS 02578+4431. The 2017 measurement for WDS 05458+3149 suggests it may be a physical double, but the nature of the system cannot be determined until further measurements are recorded.

## Introduction

The research conducted described in this paper was part of an honors project coordinated by the physics department at Grossmont College, with Dr. Sébastien Cormier and Dr. Philip Blanco acting as advisors and funded by, and with the assistance of, the Boyce Research Initiatives and Education Foundation (BRIEF).

We narrowed down a list of thousands of possible double star candidates in the Washington Double Star Catalog (WDS) to a total of six that had traits that we found significant: at least 5 previous recorded observations, an angular separation of more than six arc seconds, magnitudes no brighter than seven with a difference in magnitude of less than four between the stars, an observable change in the angle between the two stars over the course the system's recorded history, and the ability to be observed in the northern hemisphere during winter. While all six of the candidates fit these criteria, discussion about the recorded data for each star led to the decision that WDS 02578+4431 STF 328AB (hereafter referred to as STF 328) and WDS 05458+3140 BKO 310AB (hereafter referred to as BKO 310) were the best candidates for our observations. Reasoning for the criteria used to choose the best system for observation are discussed in the equipment section below.

The first observation of STF 328 is attributed to Friedrich Georg Wilhelm von Struve (1793-1864) in 1832, although the year of first discovery is listed in the WDS as 1794. This discrepancy could not be reconciled by further investigation. In addition, the two measurements made before von Struve's observation in 1832 were outliers from the normal range of the data. For the purposes of this research, the Struve observation will be considered the first observation. F.G.W. von Struve published measurements he made of double stars from 1824-1837 in his text *Stellarum duplicium et multiplicium mensurae micrometricae* (published April 1837). His first measurements of the system showed the position angle between the stars to be 299.5°, and the separation between the two to be 27.06".

The most recent observation of the system prior to our measurement was recorded in 2012 at the US Naval Observatory by astronomers Mason, B., Hartkopf, W., and Friedman, E. Their measurement, taken at epoch 2011.053, is listed as a position angle of 305.8° and separation of 15.06′′.

In the article published by Mason, Hartkopf, and Friedman, STF 328 is listed with stars that had a significant number of prior observations. The stars presented are believed to be physical doubles, with orbital paths that can be calculated. We intended to verify the accuracy of the established rectilinear solution for STF 328, and to add another data point for comparison with future observations.

Although BKO 310 is a triple star system, our

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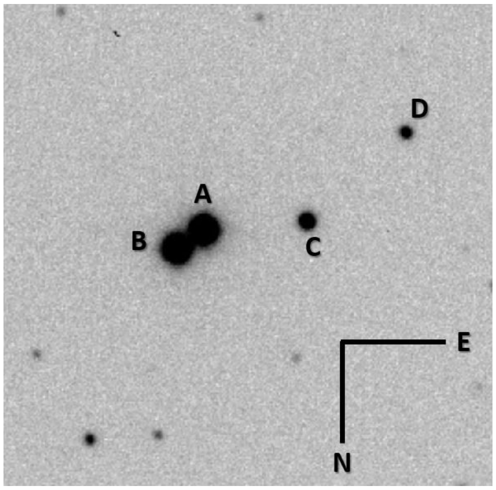


*Figure 1. Image of STF 328 taken using the T11 telescope with a Luminance filter and exposure time of 60 seconds. The primary and secondary components observed during this research are labeled A and B, respectively, with tertiary and quaternary components of the system labeled C and D, respectively.*

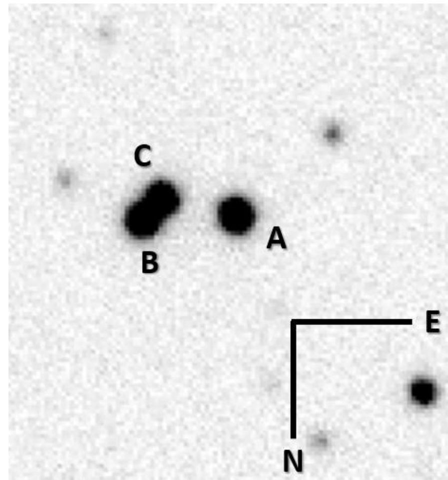


*Figure 2. An image of BKO 310 taken using the T11 telescope with a Luminance filter and an exposure time of 240 seconds. The primary and secondary components observed during this research are labeled A and B, respectively, with the system's tertiary component labeled C.*

measurements focused solely on the AB components because the last measurement by Berkó showed evidence that the BC components are optical doubles and are not physically bound. Its first measurement was recorded in 1903, with a separation of 13.86" arc seconds and theta of 248.6°. The most recent observation prior to our measurement was recorded in 2007 with a separation of 14.91" arc seconds and theta of 258.88°. The relative proper motion of BKO 310 indicates the possibility of the pair being a physical double. However, the physical nature cannot be determined currently because there have only been five measurements to date.

The first observation of BKO 310 was made in 1903 as part of an international effort to use photography to map the stars as fully as possible. Twenty observatories from various parts of the world participated in the undertaking and due to their varied locations, they were able to map a vast majority of the stars. BKO 310 was most likely photographed by an observatory in Oxford, due to the observatory's location in the northern hemisphere and the declination of BKO 310. The results from this project were formed into the Astrographic Catalogue. In the 1990's, the Astrographic Catalogue data was combined with the Hipparcos Catalogue data.

BKO 310 was last observed by Hungarian photographer and amateur astronomer Ernő Berkó. In 2007, Berkó photographed many double star systems using a digital single-lens reflex (DSLR) camera, which has a digital imaging sensor instead of photographic film. He published his observations and measurements in a series of papers of which BKO 310 was among these. Berkó's publications led to the system being assigned the discovery code "BKO 310." In Berkó's works, he discussed the possibility that the AB components of BKO 310 may be physically bound but concluded that the BC components of the system are optical doubles (Berkó 2009).

### Equipment and Observations

CCD images were taken using the T11 telescope, part of the iTelescope network, in Mayhill, New Mexico. The T11 telescope is a CDK Planewave 0.50-m f/6.8 reflector with f/4.8 focal reducer. The telescope is fitted with a FLI ProLine PL11002M CCD camera with a 4008 by 2672 array with a scale of 0.81 arc-seconds per pixel. The T11 was more than capable of distinguishing between the components of STF 328, Figure 1, and BKO 310, Figure 2, each having adequate arc second separation.

STF 328 and BKO 310 are both visible during winter with a right ascension (RA) of 02 hours, 57 minutes, 45.98 seconds for STF 328 and 05 hours, 45 minutes, 49.47 seconds for BKO 310. Both systems also have a declination (DEC) above 30°, making the T11 telescope in New Mexico a prime choice for our observations.

A total of 10 images were acquired of STF 328 at epoch 2017.878; 2 images with 60 second exposure

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times each for R, B, G, hydrogen-alpha, and luminance. One of the B filter images was omitted due to poor capture quality. The other nine images acquired provided useable data for astrometric analysis.

Eight images of BKO 310 were acquired at epoch 2017.871: two images for each of four filters, R, B, luminance, and hydrogen-alpha, with an exposure time of 120 seconds, and a second image using each filter with an exposure time of 240 seconds.

The images were processed using MaximDL V6 to insert World Coordinate System (WCS) positions into the FITS headers by comparing the images to the Fourth U.S. Naval Observatory CCD Astrograph Catalogue (UCAC4). The updated images were then loaded into Mirametrics Mira Pro x64, and algorithms in the program were used to calculate the centroids of each component of the system. Using the centroids calculated, the position angles and separation of the A and B components were measured.

## Results

The results of these measurements are listed in Tables 1 and 2.

## Discussion

The astrometric results for STF 328 were plotted with the historical data from the WDS catalogue, Figure 3, and then plotted again with the data points measured before von Struve's observation (Struve 1832) omitted, Figure 4. The system is listed in the WDS catalogue as being a known physical double, and the full data for the star seemed to suggest a possible orbit. Excluding first two data points, however, (both of which are unreliable) reveals that the components appear to be moving in linear paths, and not orbiting each other. This led to the realization that the physical nature of the two stars had been listed with a rectilinear solution, not an orbital solution. The evidence suggests that the two stars are physically bound to each other but are not orbiting each other; they are in the same system, moving in a linear motion.

We plotted the historical data with our new point alongside the motion predicted by the solved rectilinear

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*Table 1. Results of Mira Pro astrometric measurements of STF 328.*

| WDS 02578+4431 STF 328 Astrometry | | | |
|---|---|---|---|
| **Telescope: (number of images used in each filter)** | **Epoch 2017.878** | **Position Angle (degrees)** | **Separation (arcseconds)** |
| T11: 2 R, 2 B (1 used), 2 G, 2 Ha, 2 luminance 10 images total | Mean | 306.08° | 14.65" |
| | Standard deviation | 0.25° | 0.06" |
| | Standard error of mean | 0.08° | 0.02" |
| Measurement 2011.053 (Last measurement before this observation) | | 305.80° | 15.06" |

*Table 2. Results of Mira Pro astrometric measurements of BKO 310.*

| WDS 05458+3149 BKO 310 AB Astrometry | | | |
|---|---|---|---|
| **Telescopes: (Number of images for each filter)** | **Epoch 2017.871** | **Position Angle (degrees)** | **Separation (arcseconds)** |
| T11: 2 R, 2 B, 2 Ha, 2 Luminance 8 images total | Mean | 259.11° | 14.84" |
| | Standard Deviation | 0.18° | 0.04" |
| | Standard error of mean | 0.081° | 0.018" |
| 2007.254 measurement (Last one previous to our investigation) | | 258.88° | 14.91" |

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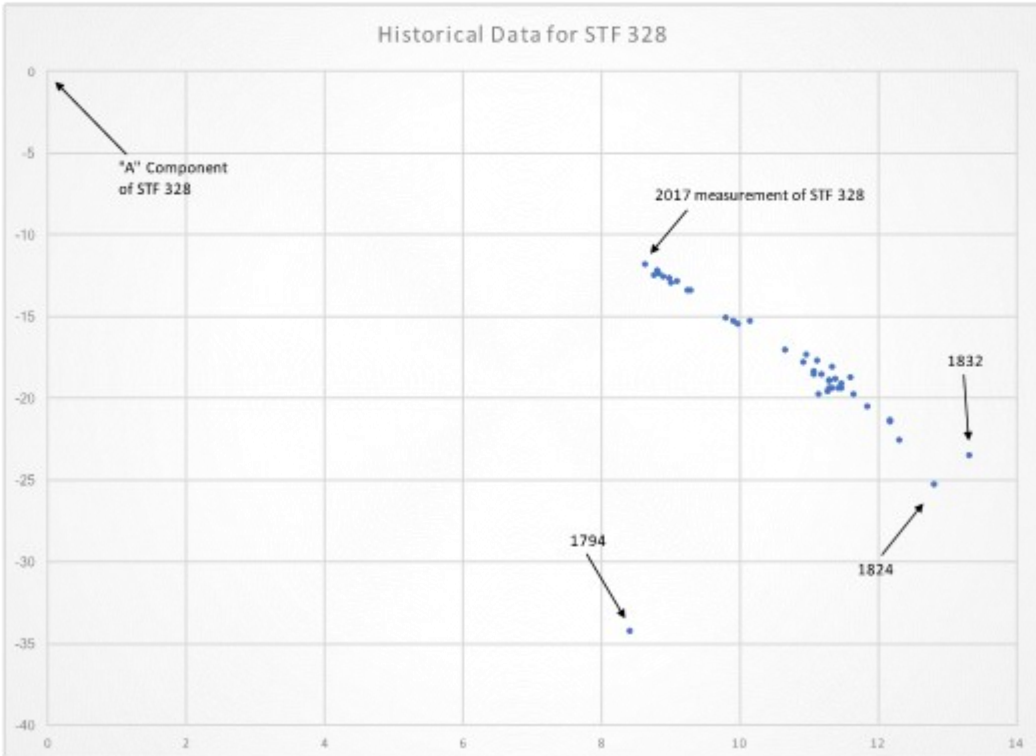


*Figure 3. Orbital plot of the primary and secondary components of STF 328, including measurements prior to the 1832 von Struve observation.*

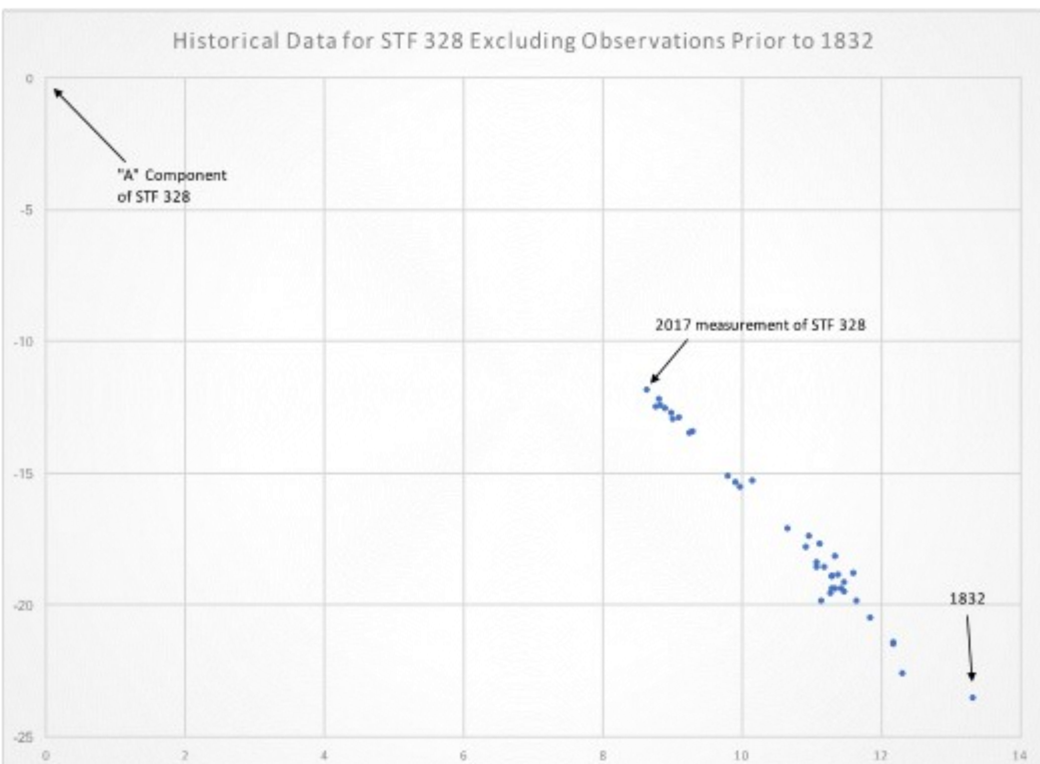


***Figure 4.*** *Orbital plot of the primary and secondary components of STF 328, excluding measurements prior to the 1832 von Struve Observation.*

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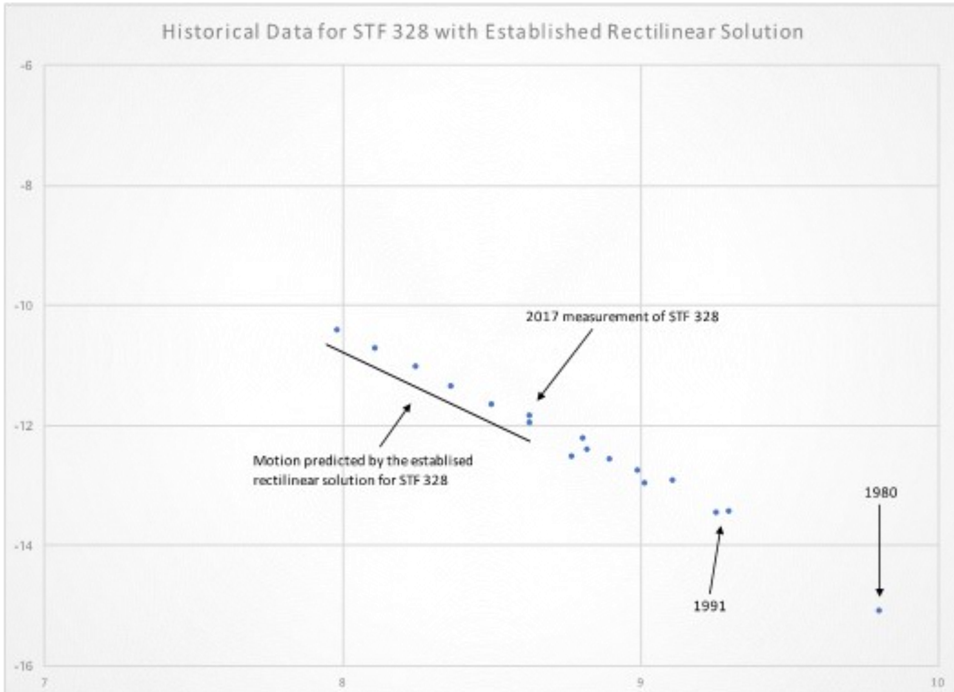


*Figure 5. Plot of the historical measurements of STF 328 with the positions predicted by the solved rectilinear solution for STF 328.*

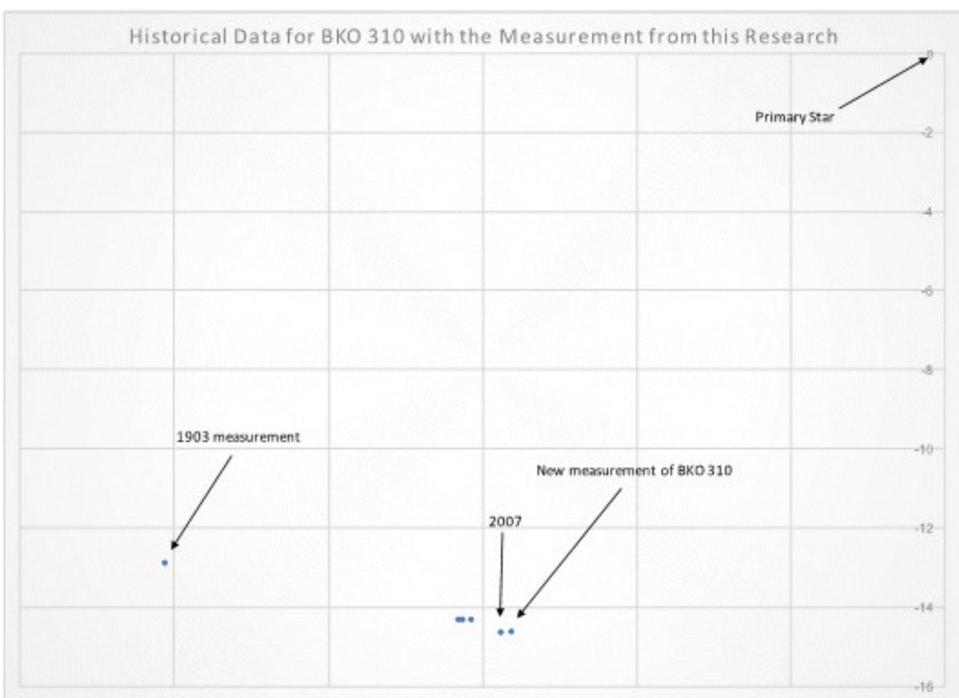


*Figure 6. A plot of the data points for BKO 310 with the new data point included. The primary star is labeled, and the secondary star's motion, with regard to the primary star, is shown by the data points*

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solution (Catalog of Rectilinear Elements), Figure 5, with the intention of verifying the accuracy of the solution. With the data graphed together, it can be seen that the solved rectilinear solution for STF 328 is accurately predicting the motion of STF 328 as of this publication.

## Conclusion

Our astrometric results from the 10 images acquired by the T11 telescope at epoch 2017.88, plotted against the historical data from the WDS catalogue, suggest that the AB components of STF 328 are not orbiting each other, but may be physically bound with a rectilinear solution. This is supported by the rectilinear solution that was published in the 2017 USNO Catalog of Rectilinear Elements. It is our opinion that the first two observations in the historical data for STF 328, both of which are dated prior to the official first discovery of the star in 1832, are inaccurate and give the system the shape of an orbital pattern that is not truly there. Future observations of STF 328 should be measured against the predictions made by the established rectilinear solution to verify its accuracy.

Our measurements of BKO 310, taken from the images acquired at epoch 2017.87 using the T11 telescope, were plotted with historical data from the WDS catalogue. We were unable to determine whether the AB components of BKO 310 are gravitationally bound, but further measurements of the system may make it possible to determine an orbital or rectilinear solution.


## Acknowledgments

The authors thank the Washington Double Star (WDS) Catalogue and the United States Naval Observatory, and specifically Brian Mason, for providing historical data for star candidates, and iTelescope for the use of their service. We would also like to thank the Boyce Research Initiatives and Education Foundation (BRIEF) for giving us this opportunity by making our research possible through their generosity, funding our use of the iTelescope network, and granting us access to their remote server and software. Furthermore, we thank Dr. Sébastien Cormier, Dr. Philip Blanco, and Naylynn Tañón for their advice and guidance during the research we conducted.

This project was supported by the Institute for Student Astronomical Research (InStAR), and with the assistance of the Boyce Research Initiatives and Education Foundation (BRIEF).


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***About the Authors***

*This research project was offered as an honors program at Grossmont College, where authors Armour, Daniyarov, Kosic, and Tañón are, attending as students at the time of this writing.*