# Astrometric Measurements of 118 Year Neglected Double Star System WDS 15229-2910

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**Abstract**: Measurements of WDS 15229-2910 SEE 232 were obtained using the Las Cumbres Observatory Network. WDS 15229-2910 was studied due to the fact that there had been no observations made in the past 118 years, and early measurements were only separated by three years (1897 and 1900) showing some movement. Through CCD astrometry, a 2018 measurement of position angle of 47.4° with an angular separation of 9.3" for SEE 232 were obtained, indicating less movement than anticipated. Subsequent research regarding the 1900 observation threw the accuracy of this observation into question, illustrating the importance of high-quality measurement and a dedication to methodology.

## Introduction

Measurements of double star WDS 15229-2910 SEE 232 were performed by four student scientists at High Tech High charter school in San Diego through the organization Boyce Research Initiatives and Education Foundation (BRIEF). Referencing the Washington Double Star Catalog (WDS), team members searched through listed double star pairs with the following criteria: right ascension between 12 and 18 hours, at least 10 years since last observation, noticeable movement between stars over first and last measurements in both position and angle, and an unclassified nature. Possible star candidates were compiled and discussed until a primary research candidate was selected.

Initial curiosity about WDS 15229-2910, the chosen double star, stemmed from the absence of recent observations and lack of numerous historical measurements having only recorded measurements in 1897 and 1900. Within this three-year gap, the difference in both separation and angle had dramatically changed, uncharacteristic of double star pairs. The goal of the measurements was to determine whether this pair exhibits unique rapid motion or if the basic measurement tools used in 1897 and 1900 inaccurately represented this star pair.

## History of 15229-2910 SEE 232

WDS 15229-2910 SEE 232 was first discovered by T.J.J. See in 1897, but first measured by Cornell Astronomy Professor S.L. Boothroyd. The second measurement was taken in 1900 by W.A. Cogshall, a binary star observer who had worked as T.J.J See's assistant for several years when See worked at the Lowell Observatory in Flagstaff Arizona. In the three-year span between these early measurements, one might expect little movement; however, there was enough change to make further measurement worthwhile. The group hypothesized that there would be significant movement - enough to tell if the binary star system was visual or gravitational - since so much time (118 years) had passed since the last measurement and the early measurements (separated by just three years) showed such significant movement. However, upon further analysis, the results are a little less extraordinary with only a small amount of movement. The aspect that seems the most exciting is that the profile of the stars - a delta mag of 4 and difference in arcseconds being 3.44".

The original measurement of SEE 232 in 1897 had a theta (position angle) of 51.2° and rho (separation) of 8.47". At the next observation in 1900, theta had changed to 44.6° and rho to 5.03". As for the magnitude of the star, the primary is 8.94 with a spectral type of M1/2, a red star, with a luminosity class of III, indicating the star has left the main sequence and begun to swell into a red giant as its internal structure changes.

The original observer of 15229-2910 was Thomas Jefferson Jackson See. See was a respected telescopic observer early in his career with a solid background in celestial mechanics. In 1900, Wilbur A. Cogshall, an astronomy professor at Indiana University and Director of the Kirkwood Observatory from 1907-1944 made the second observation. Interestingly, Cogshall worked as See's assistant while See was at the Lowell Observatory in Arizona.

In the historical data that was requested for 15299-2910 there were two observations from 1897 and 1900, but four total entries. The entries from 1932 and 1991 only related to the proper motion. The theta and rho were not recorded, which means that there were technically only two measurements in 118 years.

## Materials and Methods

Images were taken using the expansive Las Cumbres Observatory (LCO) network, a grouping of nine observatories able to continually capture the night sky due to their diverse locations across the planet. Each observatory is outfitted with multiple types of telescopes, however a modified Meade 0.4-meter telescope outfitted with a charge coupled device (CCD) camera was used to capture images of SEE 232. The images were ordered through the LCO online observing portal where filters, exposure length, and time window for the images were selected. Five image requests were submitted with four successfully completed. Each subsequent imaging request was based on knowledge developed from analysis of previous images regarding exposure lengths and filters. The most successful filters were: Sloan Green, Bessell Blue, Bessell Violet, and Pan-STARRS W.

Once the images were taken by the telescopes, the data processed through the Our Solar Siblings Pipeline (OSS). The OSS Pipeline (Fitzgerald 2018) is comprised of multiple parts that run sequentially to clean, label, and calibrate images. This process reduced the steps needed to prepare the photos for later measurement. Images spend roughly three days in the OSS Pipeline before being transferred to the group's shared folder.

After the OSS pipeline, images were further refined using the Vertical Transfer Function tool in Mira Pro by setting the saturation to 99.5% or 99.9% dependent on image to ensure image clarity. If an image was still noisy with the target stars unidentifiable, the photo was not used. Usable images were then measured using the Distance & Angle tool in Mira Pro. This tool was used to find the center of the A star. Due to the close proximity of the secondary, and large delta magnitude of the pair, the center of the B star was determined by eye.

The angle and separation of the stars were recorded and organized in an Excel spreadsheet by filter. Utilizing the functions found on Excel and a calculator created by BRIEF, the mean calculations, standard deviation, and the deviation of error were determined and recorded by filter. The calculated measurements by filter were then averaged to find the position and separation angles that would be used.

## Data and Results

Theta and Rho measurements are given in Tables 1 and 2 respectively. Table 3 summarizes the results.

## Discussion

The primary star is listed with a magnitude of 8.94 and the secondary star has a magnitude of 13.00, making the delta mag 4.06. Using Wien's law, Figure 1, star's stellar type and luminosity class of MIII, a cool red giant producing more light at longer red wavelengths than other shorter wavelengths, were considered in filter choice. A CCD image using a red filter will result in a larger star image than using a blue short wavelength filter as the primary has higher light output in the red part of the spectrum. The transition from longer to shorter wavelengths (red, green, to blue), Fig-

*Table 1. 2018 Rho Measurements.*

| Filter | Red | Green | Blue | Visual | W |
|---|---|---|---|---|---|
| **Average** | 9.4" | 9.5" | 8.7" | 9.2" | 9.7" |
| **Standard Deviation** | 0.15" | 0.24" | 0.32" | 0.31" | 0.27" |
| **Standard Deviation of the Average** | 0.068" | 0.081" | 0.13" | 0.137" | 0.133" |

*Table 2. 2018 Theta Measurements.*

| Filter | Red | Green | Blue | Visual | W |
|---|---|---|---|---|---|
| **Average** | 46.97° | 47.90° | 47.61° | 46.70° | 47.81° |
| **Standard Deviation** | 0.68° | 0.74° | 0.83° | 1.28° | 1.39° |
| **Standard Deviation of the Average** | 0.303° | 0.11° | 0.165° | 0.426° | 0.464° |

*Table 3. Summary Data Across All Filters and Measurements.*

| Average Rho | STDEV | STDEV of the Average |
|---|---|---|
| 9.3" | 0.38" | 0.076" |
| Average Theta | STDEV | STDEV of the Average |
| 47.4° | 0.53° | 0.107° |

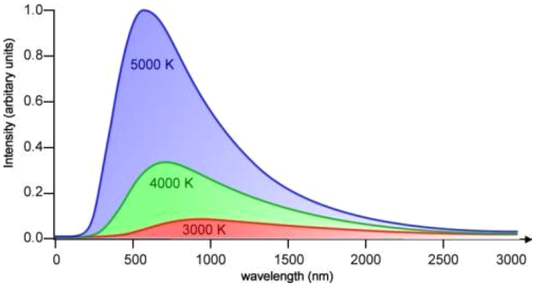

*Figure 1. Example of Wien's Law applied to stars of different temperatures, stellar class. (Source: Curious Astronomer WEB).*

*Table 4. Summary of data by year taken*

| Epoch | Theta | Rho |
|---|---|---|
| **1897.54** | 51.2° | 8.47" |
| **1900.44** | 44.6° | 5.03" |
| ***2018.247*** | *47.4°* | *9.3"* |

ure 2, through the use of filters, enabled a reduction of the primary star's size on the CCD image as an MIII star produces less blue (shorter) wavelengths than red (longer) wavelengths. This enabled a clearer definition between the two stars.

Since the difference in arcseconds was so small between the primary and secondary stars, Mira Pro could not automatically capture the center of the secondary star, therefore it had to be located by hand. In Table 1, the data showed the standard deviation between the data points with different filters had more variance than the standard deviation of the mean. This leaves the question of how exact the measurements actually were. In addition to the fact that the tool could not be used to automatically determine the center of the secondary star, the fact that measurements were made by different group members also contributed to the variation in measurements.

There are only three total measurements related to this star pair, including our 2018 measurement, Table 4. The combined measurements do not indicate a trend outlining a clear pattern of the double star's behavior over the 121 years since initial measurement. Using an Excel plotting tool developed by Richard Harshaw, Figure 3, the data suggests it is most plausible that the star did not move as drastically as first thought and that the 1900 measurement may be miscalculated. Figure 3 suggests that the 1897 and 2018 measurements match more closely than the 1900 coordinate.

## Conclusion

A binary star pair can be a good candidate for study if it has not been measured for at least a decade and this team's chosen pair met that criteria having not been measured in 118 years. It seemed like an exciting prospect for measurement and analysis. The star pair seemed to have a large movement in the short span of three years with the initial measurements and in the next 118 years the star's movement was minimal.

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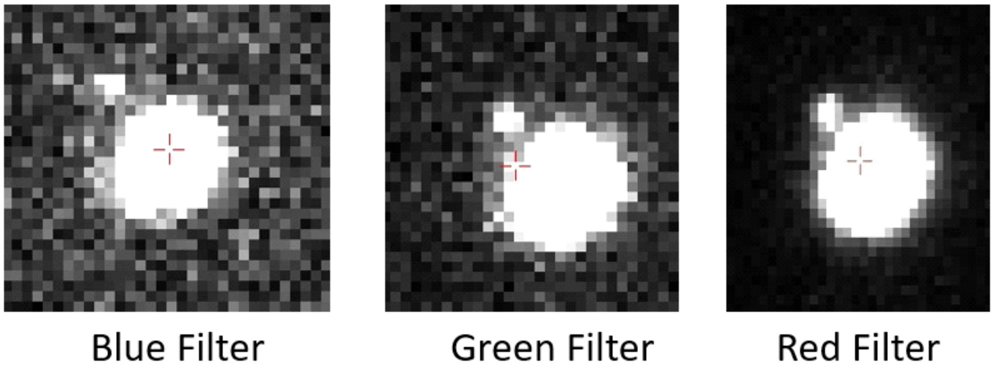
Blue Filter
Green Filter
Red Filter

*Figure 2. Transition from shorter to longer wavelength filters. Note the noise increased with shorter wavelength, but the separation between the stars also increased ensuring a more accurate measurement.*

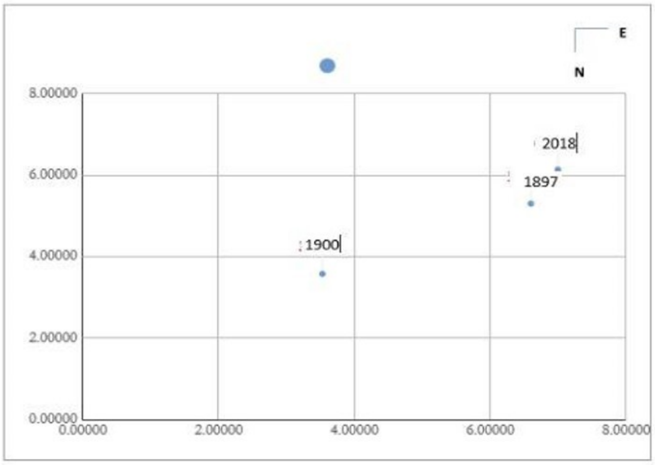

*Figure 3. Plotted Historical measurements.*

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