# Analysis of the WDS 16014-6710 NZO 68 through astrometric measurements

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**Abstract**

This research delves into the analysis of the WDS 16014-6710 NZO 68 (HD 142877) system, located within the Triangulum Australe constellation. Utilizing our observations, data from the Gaia Data Release 3 mission, and historical records, we obtained new measurements of the position angle and separation. The results indicate a position angle of 246.3° and a separation of 6.90″. Furthermore, an exploration of the parallax suggests that the stars in the system are far apart and not gravitationally bound, but the proper motion values suggest they are common proper motion pairs. Consequently, the WDS NZO 68 double-star system is classified as a physical double-star. To affirm this conclusion, we advocate for future studies to monitor dynamic changes in system parameters.

## 1.0 Introduction

Double stars, i.e., systems of two stars that appear close to each other when observed in the sky, can be classified into two physical types: binary stars and optical doubles. The former are stars that are gravitationally bound to each other, whereas the latter are not, but merely appear close together in the sky (Marcel et al., 2024). The study of double stars is important because it aids in deciding whether the studied stars are binaries or optical doubles and in the measurement of stellar masses (Ersteniuk et al., 2024).

The target double star for this study is WDS 16014-6710 NZO 68, first observed in 1895 (Urban et al., 1998). The system is located in the constellation Triangulum Australe, with coordinates RA = 16h 01m 23.02s and Dec = -67° 10' 00.0". For this research, we analyzed historical data from the Washington Double Star Catalog (Mason et al., 2001), the Gaia Data Release 3 mission (Gaia Collaboration et al., 2022), and new data from the Las Cumbres Observatory to determine its position angle and separation and to assess whether it is a binary star or an optical double.

Table 1. The Right Ascension (RA), and Declination (Dec) were retrieved from the Washington Double Star (WDS) catalog, the magnitudes of the primary and secondary stars were taken from the Gaia Gmag database, the parallax and proper motion of the primary and secondary stars were taken from the Gaia catalog, and the rPM was calculated from the proper motions of the system.

| | Gaia Gmag | Parallax (mas) | Distance (parsec) | Proper Motion (mas/yr) | rPM |
|---|---|---|---|---|---|
| Primary Star | 10.220 | 0.9217±0.01444 | 1084.95 | pmra= -4.841±0.0084<br>pmdec= -8.399±0.0120 | 0.02503 |
| Secondary Star | 11.800 | 0.8233±0.11936 | 1214.62 | pmra= -5.086±0.0115<br>pmdec= -8.424±0.0166 | |

Table 1 presents known information about the system under study. The data is collected from Gaia Data Release 3 and the Washington Double Star Catalog. The proper motion ratio (rPM) of this system was calculated from the proper motions of the primary and secondary stars following the methodology described by Harshaw (2016)

$$\text{Resultant} = \sqrt{(R_{pri} - R_{sec})^2 + (D_{pri} - D_{sec})^2}$$

$$\text{Vector} = \sqrt{R^2 + D^2}$$

$$\text{rPM} = \frac{Resultant}{Vector}$$

with $R_{pri}$ and $D_{pri}$ representing the proper motion, respectively, in Right Ascension and Declination of the primary star, $R_{sec}$ and $D_{sec}$ representing the proper motion, respectively, in Right Ascension and Declination of the secondary star, $R$ and $D$ representing the proper motion, respectively, in Right Ascension and Declination of either the primary and secondary star, but whose vector is higher.

Knowing that the rPM is a measure of how different the proper motions of the two stars are from each other relative to the size of the larger proper motion, rPM<0.2 implies that the stars in the system are likely to be a Common Proper Motion (CPM) pair. Moreover, if the rPM is less than 0.6, then the stars

have Similar Proper Motion (SPM), and if the rPM is > 0.6, then they have Different Proper Motion (DPM). Consequently, as the calculated value of rPM = 0.02503, being less than 0.2, the two stars of the NZO 68 double-system have a common proper motion.

### 1.1 Target Selection

Stelle Doppie, which is a website that can access the database of the Washington Double Star Catalog (WDS) for double-star systems, was used to select the double-star system of interest. We used a right ascension (RA) range of 16 hours and above and up to 3 hours so that the systems would be observable during the time of this study. This range of RA was found using Stellarium, a free software that simulates the sky. There were no restrictions on declination (Dec) as there are several 0.4m LCOGT networks mounted on both hemispheres. In order to maximize the chances that the system's astrometry would change significantly, only stars observed by 2016 were selected. We chose the magnitude of the primary star to be between 9 and 11 so that it could be observed by the 0.4m LCO with a limit of 20.5 magnitudes. We set the difference in magnitude (Δmag) between the primary and secondary stars to be less than 4 so that both stars would be visible. We also chose the separation to be between 5 and 10 arcseconds so that they could be easily resolved as two separate stars in images taken by the LCO. We got 105 search results from which we selected NZO 68 as a worthy double-star system.

WDS NZO 68 became the central focus of our investigation due to several noteworthy factors:

1. Its nature is uncertain.
2. There have been noticeable changes in its parameters between the first measurement in from the last measurement in 2016.
3. It has been studied five times.

## 2.0 Methodology

On April 29, 2024, 10 images of the WDS 16014-6710 double star system, with an exposure time of 2 seconds each, were obtained from the observation through the 0.4m LCO Observatory in Sutherland, which is part of the Las Cumbres Observatory's Global Telescope (LCOGT) network. The observatory has SCICAM QHY600 cameras with a pixel scale of 0.73" per pixel in 1 × 1 binning mode and 30' × 30' field of view.

The Bessell-V filter (Bessell, 1990) was used for our observations. The LCO processed all image files automatically using their BANZAI pipeline. After acquiring the 10 images, we used the AstroImageJ program (Collins et al, 2017) to measure the separation and position angle of our systems from the images by choosing an aperture size of 3 pixels. AstroImageJ allows the user to find the centroid of the star automatically using the position that represents the weighted average of the pixel brightnesses within a chosen aperture. After selecting the aperture size and zooming into the image region where the stars are located, the user command-drags the cursor from the primary to the secondary star to obtain the PA and Sep (shown as ArcLen). We requested historical data for the systems from Dr. Rachel Matson at the Washington Double Star Catalog and plotted the new and historical measurements using Google Sheets.

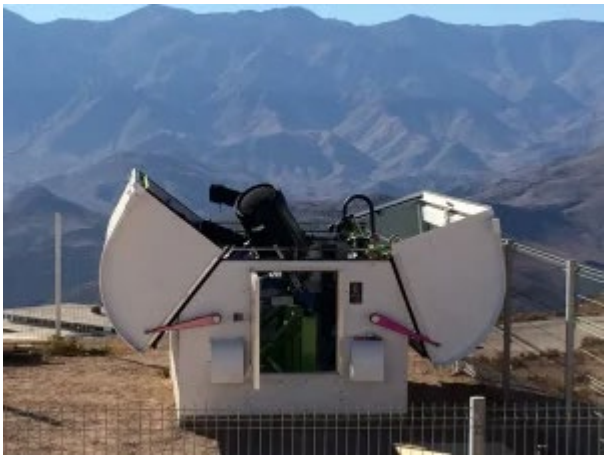

Figure 1: 0.4 m telescope located at one of Las Cumbres Observatory's sites

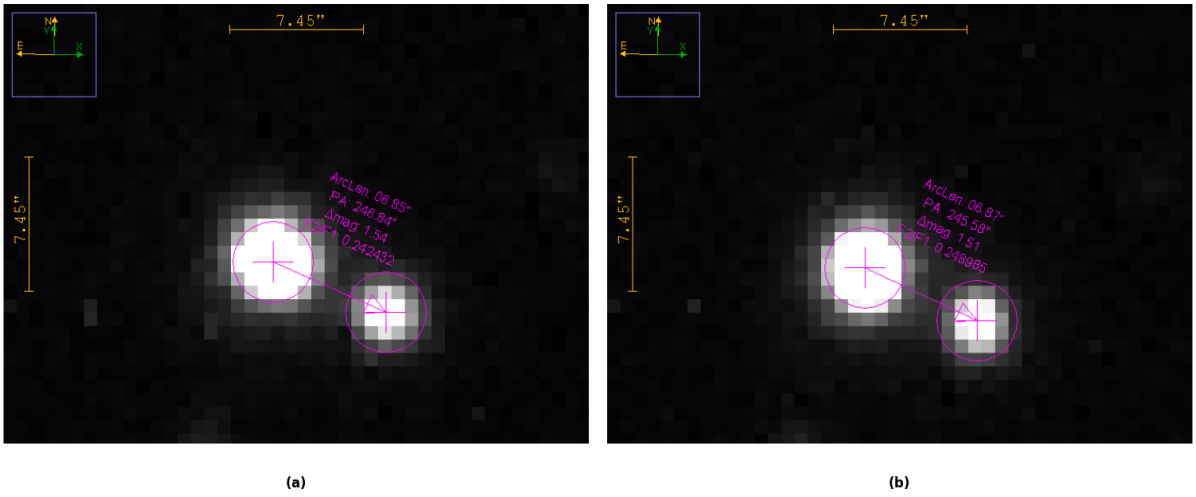


Figure 2. Astrometry process on WDS 16014-6710 using AIJ. The measurement starts from the primary star and is dragged to the secondary star. The readings in pink indicate the position angle and separation.

### 3.0 Observation

Table 2 shows the new measurements we got from our ten images. Table 3 summarizes the statistical analyses we did on these measurements.

Table 2. New measurements of WDS NZO 68 derived from our images.

| Image Number | Position Angle (°) | Separation (") |
|---|---|---|
| **1** | 248.84 | 6.85 |
| **2** | 245.58 | 6.87 |
| **3** | 246.04 | 6.94 |
| **4** | 246.06 | 6.87 |

| | | |
|---|---|---|
| **5** | 245.90 | 6.83 |
| **6** | 246.44 | 6.96 |
| **7** | 246.45 | 6.86 |
| **8** | 245.45 | 6.92 |
| **9** | 245.38 | 6.90 |
| **10** | 246.52 | 7.00 |

Table 3. Mean, standard deviation, and Standard error of the mean of our measurements WDS NZO 68.

| **Double star** | **Date** | **Images** | | **PA(º)** | **Sep (")** |
|---|---|---|---|---|---|
| WDS 16014-6710 NZO 68 | 29th of April, **2024** **(2024.3251)** | **10** | Mean | 246.3 | 6.90 |
| | | | Standard Deviation | 0.995 | 0.05 |
| | | | Standard Error of the mean | 0.31 | 0.017 |

**4.0 Discussion**

We present the results of our study of WDS NZO 68, a double star system, with the new position angle and separation measured at 246.3° and 6.90″, respectively. The previous values were 245.9° and 6.94″. Based on historical data and our new measurements, we illustrate the variation in the separation of the double star system in Table 4 and plotted in Figure 3. The system has been observed five times, with contributions from Urban et al. (1998), Hartkopf et al. (2013), and Høg et al. (2000).

Table 4. List of the system's historical data from the Washington Double Star Catalog in different numbers of decimal places.

| Year | Position Angle | Separation |
|---|---|---|
| 1895.98 | 246.4 | 6.50 |
| 1998.258 | 246 | 6.92 |
| 2000.3 | 245.7 | 6.94 |
| 2010.256 | 246.4 | 7.00 |
| 2016 | 245.9 | 6.94 |
| 2024.3251 | 246.3 | 6.90 |

We plotted the historical astrometric data of the system as presented in Table 4. Figure 3 shows the data points from previous studies as blue dots, while our new measurements are represented

by a green dot. The plot displays the relative position of the secondary component with respect to the primary in right ascension and declination offsets, rather than the position angle and separation values listed in the table.

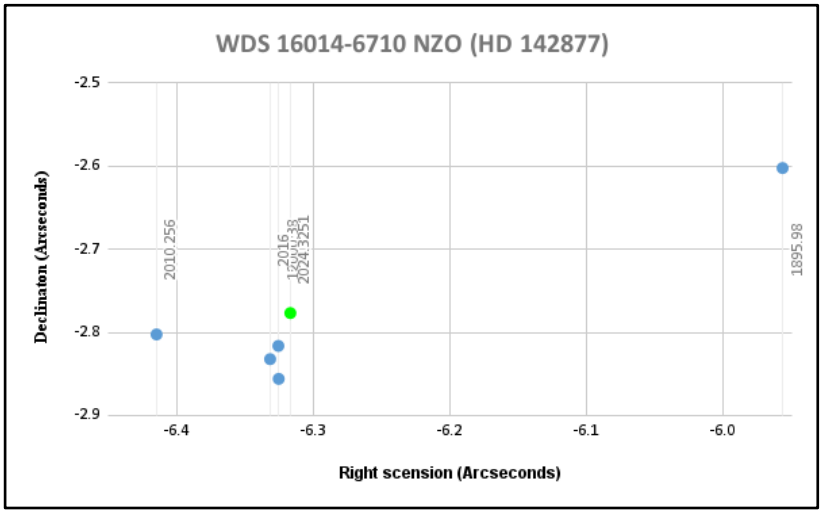


**Figure 3.** Plot showing the historical astrometric data (blue dots) and the new measurements (green dot) for the double star system WDS NZO 68. The plot represents the relative right ascension (ΔRA) and declination (ΔDec) of the secondary component with respect to the primary, not the position angle and separation directly from Table 4

Table 4 presents historical data from the initial observation of WDS NZO 68 in 1895 to our latest data contribution in 2024. Examining the star system's position angle and separation shows that they have fluctuated erratically over the years of its study. This irregularity is primarily ascribed to atmospheric effects, data noise, and overall measurement uncertainty. The graphical representation of this trend is illustrated in Figure 3, with the blue data points representing previous measurements and the green data point signifying our measurements. Based on this pattern, no plausible prediction can be made about whether these values will increase or decrease in the future.

Another feature of the WDS NZO 68 system is the parallax values of the primary and secondary stars, which are 0.9217±0.01444 mas and 0.8233±0.11936 mas, respectively. These values, even accounting for error in the parallax, suggest that the stars are not close to each other and are not gravitationally bound.

The proper motions (in RA and Dec) of the system, presented in Table 1 and used to calculate the ratio of proper motion (rPM) metric, resulted in a value of 0.02503, which is below 0.2. This implies that the system is a Common Proper Motion (CPM) pair. According to Harshaw (2016), CPM pairs are potential indicative of binary systems.

**5.0 Conclusion**

In conclusion, this study has focused on the double star system WDS NZO 68, examining the measurement of its position angle and separation, comparing it with historical data, and calculating the parallax and proper motion for both the primary and secondary stars. The key findings of our investigation are as follows:

The updated position angle and separation of the system are 246.3° and 6.90″, respectively. The previous values were 246.4° and 7″. However, it is challenging to predict whether these parameters will increase or decrease in the future due to atmospheric effects, data noise, and overall measurement uncertainty.

The the system's parallax implies a distance difference of 129.67 parsecs, indicating that the stars are far apart and not gravitationally bound.

The ratio of proper motion (rPM) metric is 0.02503, which is below 0.2. This implies that the system is a Common Proper Motion (CPM) pair.

Despite the plot in Figure 3 and Table 4 displaying an erratic and unpredictable trend, the parallax data suggests that the system's stars are not close, and the rPM data shows they have the same speed. This leads us to conclude that the system may be a physical double. Physical double systems are pairs of stars moving together and co-located in space without being gravitationally bound to each other. We suggest conducting additional studies to track the dynamic changes in the system's parameters, which will help to confirm our conclusions and deepen our understanding of this celestial system.

**Acknowledgments**

This research was made possible by the Washington Double Star catalog maintained by the U.S. Naval Observatory. We would like to express our appreciation for the resources provided by the StelleDoppie catalog, managed by Gianluca Sordiglioni, as well as the assistance from Astrometry.net and the AstroImageJ software developed by Karen Collins and John Kielkopf.

Additionally, we acknowledge the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), and we are grateful for the data processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for DPAC has been generously provided by national institutions, especially those participating in the Gaia Multilateral Agreement.

Our observations benefited from the 0.4m telescopes of the Las Cumbres Observatory Global Telescope Network at the Sutherland Observatory.

Special thanks to the Pan-African Citizen Science e-Laboratory (PACS e-Lab) management for facilitating this research opportunity in Africa. We also extend our gratitude to Gianluca Sordiglioni for maintaining the informative Stelle Doppie site, Dr. Rachel Freed for the recorded research guide, and Kalee Tock for creating the plotting instructions.

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