New Astrometric Measurements of the Double-Star System WDS 18234-4819 B 938

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Abstract

This research delves into the analysis of the WDS 18234-4819 B 938 double-star system situated within the Telescopium constellation. Utilizing our observations, data from the Gaia Data Release 3 mission, and historical records, new measurements of the position angle and separation were acquired. The results indicate a position angle of 342.6° and a separation of 8.39", showcasing an observable increase in comparison to historical data. Furthermore, an exploration of the parallax and proper motion values suggests disparate distances from Earth and a lack of gravitational binding between the stars. Consequently, the WDS 18234-4819 B 938 double-star system is classified as an optical double. To affirm this conclusion, we advocate for future studies to monitor dynamic changes in system parameters.

1.0 Introduction

A double star is a system of two stars appearing close to each other visually. They are classified into optical doubles and binaries. Binary stars are gravitationally bound to each other and orbit a common center of mass. In contrast, optical double stars are not gravitationally bound but are located at different distances from the Earth but have similar coordinates (Marcel et al., 2024).

In our Milky Way Galaxy, approximately 50% of all star systems are binary stars (Kroupa, 1995), so it’s important to study them. Studying binary stars is essential for understanding stellar evolution, mass transfer, and star formation (Li and Han, 2008).

One method of observing and studying double stars is to use CCD cameras that convert the light that falls on them into electrical signals (Peterson, 2001). Due to the high resolution of a CCD camera, it is possible to determine the position angle and separation of the double stars. Because of their helpful properties (high quantum efficiencies), they are widely used for astronomical observations in UV-to-infrared applications. The CCD camera can take pictures of nearby objects, such as the Moon, and distant ones, such as other galaxies.

In this paper, we present our observation on a double-star system called WDS 18234-4819 B 938. It is in the Telescopium constellation at coordinates RA = 18h 23m 25.93s and Dec = -48° 18' 54.2". We are using data from different sources, like the Washington Double Star Catalog and the Gaia Data Release 3 mission, which gives us precise measurements of celestial objects. We also added some new data from the Las Cumbres Observatory global telescope.

We measured the position angle and separation of the double star parts and compared them with historical data from the Washington Double Star Catalog. We discuss what the system might be like based on our observations and analysis. Our goal was to figure out if it is just two stars that look close together or if they are orbiting each other. This classification is important for understanding how the system works.

Table 1 has information about the stars, gathered from Gaia Data Release 3 and the Washington Double Star Catalog.

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	9.93559	5.7861	172.828	pmra = 7.090 pmdec = -88.180	0.963
Secondary Star	13.897545	0.7830	1277.139	pmra = 10.493 pmdec = -3.050	

The proper motion (PM) of the double star system is detailed in column 5 of Table 1 above, specifically in the Right Ascension (RA) and Declination (Dec). These values were utilized to compute the ratio of proper motions (rPM) metric. The concept of rPM, introduced by Harshaw (2016) (equations delineated below), represents the magnitude of the disparity between the proper motions of the primary and secondary stars, divided by the larger magnitude of the two proper motions. Essentially, rPM gauges the extent to which the two proper motions deviate from each other relative to the magnitude of the larger proper motion. Should the rPM of the stars fall below 0.2, it suggests that the stars likely form a Common Proper Motion (CPM) pair. If the rPM surpasses 0.2 but remains below 0.6, it indicates that the stars exhibit Similar Proper Motion (SPM). Conversely, if the rPM exceeds 0.6, the stars possess Different Proper Motion (DPM). Applying this framework, WDS 18234-4819 B 938, with an rPM metric value of 0.963, signifies that the system comprises Different Proper Motion (DPM) pairs.

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

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

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

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

1.1 Target selection

To select the double-star system to study, we used Stelle Doppie. This website can access the Washington Double Star Catalog (WDS) database for double-star systems, to select the double-star system of interest. We chose a right ascension (RA) that is not between 5 and 17 so that the system would be visible during the study. The declination constraint was unnecessary, as several 0.4-meter LCO telescopes are located in the northern and southern hemispheres. We chose stars that were observed before 2010 so that the position angle and separation changed sufficiently. We limited the apparent stellar magnitude so that the host star had an evident stellar magnitude between 9 and 11; the upper value was chosen so that the star could be observed in this 0.4-meter telescope, while the lower value was determined so that the star was not too bright and not very much explored. The difference in apparent star magnitudes was chosen to be less than 4 so that both stars would be visible in the images. We choose the separation between 5 and 10 arcseconds to possibly resolve them as two separate stars in images taken by the LCO.

The WDS 18234-4819 B 938 star system was chosen for several reasons:

1. It has only been studied five times, from its first observation in 1927 to its last in 1999.
2. The nature of this system is uncertain.
3. 25 years have passed since the last study of this system, so position angle and separation could have changed quite a lot, and the stars could have moved relative to each other.

2.0 Methodology

On February 27, 2024, we used the 0.4m Cerro Tololo facility in Chile, which is part of the Las Cumbres Observatory's Global Telescope (LCOGT) network, to take 10 images of our systems with an exposure time of 2 seconds each. The observatory has SBIG 6303 cameras, which have a pixel scale of 0.571 and a field of view of 29′x19′. We used the Bessell-V filter for our observations. The LCO processed all image files automatically using their BANZAI pipeline. After that, we used the AfterGlow Access program to change the saturation level of the image to make it more convenient to take measurements. The program allows you to find the centroid of the star automatically (centroid clicks function). We measured the separation and position angle of our systems from the images, as shown in Figure 2.

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.

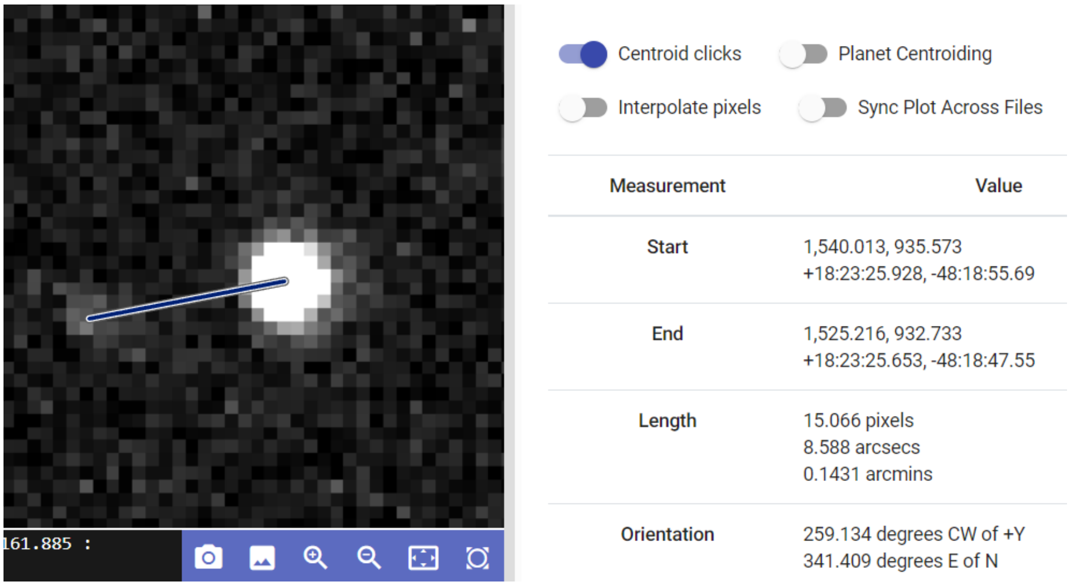

Figure 2: A screenshot from AfterGlow Access showing the measurement of position angle and separation of WDS 18234-4819 B 938.

3.0 Observation

Table 2 presents the newly acquired measurements obtained from our ten images. Table 3 provides a comprehensive summary of statistical analyses conducted on our measurements.

Table 2: New measurements of WDS 18234-4819 B 938 derived from our images

Image number	Position angle (°)	Separation (″)
1	341.2	8.11
2	341.3	8.65
3	341.5	8.64
4	343.0	7.73
5	341.4	8.59
6	342.9	8.32
7	344.5	8.59
8	343.6	8.17
9	342.7	8.59
10	343.5	8.49

Table 3: Mean, standard deviation, and Standard error of the mean of our measurements
WDS 18234-4819 B 938

Double-Star	**Date**	**Images**		**PA(°)**	**SEP('')**
WDS 18234-4819 B 938.	27 February 2024 (2024.158)	10	Mean	342.6	8.39
			Standard Deviation	1.15	0.303
			Standard Error of the Mean	0.36	0.096

4.0 Discussion

We present the results of our study of WDS 18234-4819 B 938, a double star system, with the new position angle and separation measured at 342.6° and 8.39″, respectively. The previous values were 339° and 6.99″. 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, by the contributions of Zacharias et al. (2013), Van den Bos (1962), and Kuruwita et al (2022)

Table 4: list of the systems' historical data sent by the Washington Double Star Catalog. They have different numbers of decimal places.

Year	Position angle (°)	Separation (″)
1927.6	286	2.12
1940.33	307.9	2.55
1951.69	317.4	2.90
1998.73	338.8	6.90
1999.72	339	6.99
2024.16	342.6	8.39

We plotted the historical data of the system from Table 4. The plots in Fig 3 show the data points following a trend from bottom to top, with the following color sequence: Red (R), Red (R), Orange (O), Yellow (Y), Green (G), and Blue (B). The blue data point represents our measurements.

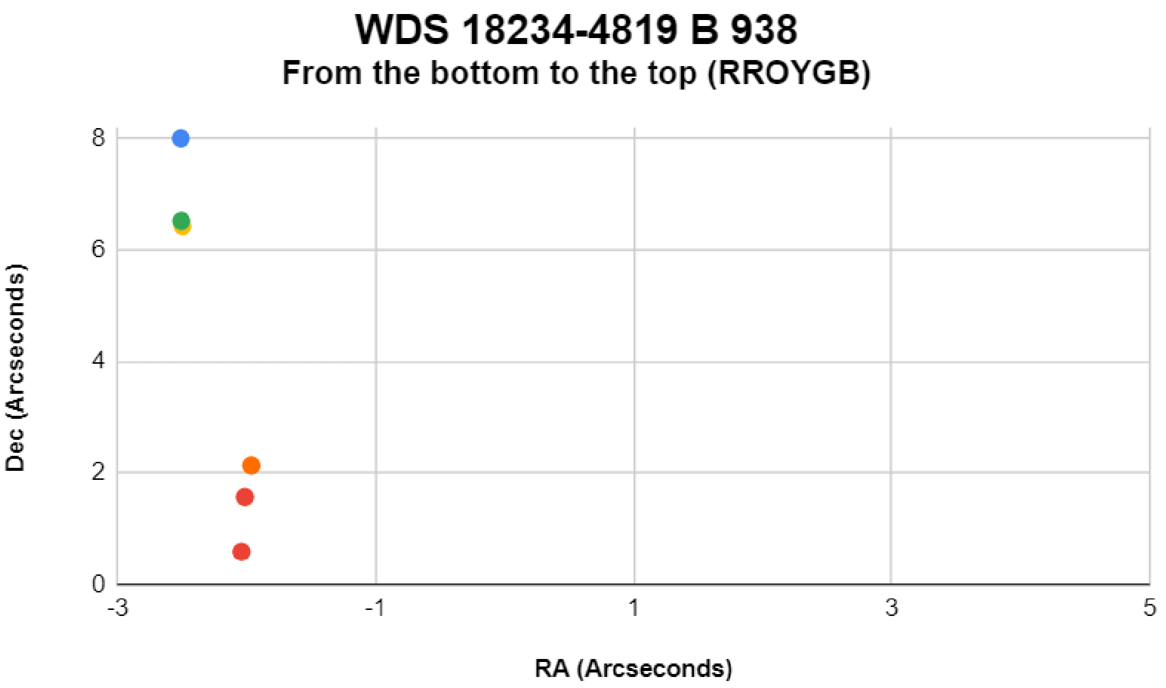

Figure 3: Plot of historical data and the new measurements of WDS 18234-4819 B 938,

Table 4 presents historical data spanning from the initial observation of WDS 18234-4819 B 938 in 1927 to our latest data contribution in 2024. An examination of the star system's parameters reveals a progressively non-uniform linear trend over time. 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, following the color sequence Red (R), Red (R), Orange (O), Yellow (Y), Green (G), and Blue (B), with the blue data point signifying our measurements. Thus, based on the established pattern, we anticipate a continued increase in parameters, especially separation, in the future.

Another noteworthy feature of the WDS 18234-4819 B 938 double star system is the parallax values of the primary and secondary stars, which stand at 5.7861 mas and 0.7830 mas, respectively. These values suggest that the systems are situated at different distances from Earth, indicating their lack of proximity and absence of gravitational binding. This is also indicated by the linear trend in Fig 3 above.

To support this claim, the proper motions (in RA and Dec) of the system, presented in Table 1 and utilized to calculate the ratio of proper motion (rPM) metric, resulted in a value of 0.963 (rPM > 0.6). This implies that the system is a Different Proper Motion (DPM) pair. According to Harshaw (2016), DPM pairs are indicative of non-binary systems.

Furthermore, Figure 3 displays a linear-like trend, and Table 4 indicates an increasing separation within the system. This, combined with the data from rPM and parallax, leads us to the conclusion that the system is not gravitationally bound; rather, it consists of optical double pairs.

5.0 Conclusion

In conclusion, this study has involved a thorough examination of the double star system WDS 18234-4819 B 938, focusing on the measurement of position angle and separation, comparison with historical data, and the calculation of parallax and proper motion for both primary and secondary stars. The key findings of our investigation are as follows:

The position angle and separation of the system have exhibited a significant increase over time, progressing from 339° and 6.99" in 1999 to 342.6° and 8.39" in 2024, respectively. The parallax values of the primary and secondary stars, measuring 5.7861 mas and 0.7830 mas, respectively, suggest differing distances from Earth, indicating a potential lack of gravitational binding and categorizing the system as an optical double.

The ratio of proper motion (rPM) metric for the system is 0.963, which is more than the threshold of 0.6. This categorizes the system as a Distinct Proper Motion (DPM) pair, in alignment with the established criteria above.

The linear-like trend observed in the plots and the increasing separation within the system, together with the collective evidence from the rPM and parallax data leads us to the definitive conclusion that the system is not gravitationally bound. Instead, it is composed of optical double pairs. We recommend further studies to monitor the dynamic changes in system parameters, thereby confirming our conclusion and enhancing the understanding of this celestial system.

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