Astrometric Measurements of WDS 21143+2522 AB and WDS 21139+2512 in Vulpecula

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Abstract: New astrometric measurements for the binary systems WDS 21143+2522AB (POU5283) and WDS 21139+2512 (POU5276) were observed. Images were requested and received from the Las Cumbres Observatory Global Telescope (Image 3) of these systems on July 7th, 2022 from the observation node in Tenerife, Spain and individual images provided by Team members (Image 1). The program AstroImageJ was used to measure the PA and Sep of the secondary star to the primary within these systems. New astrometric measurements for WDS 21143+2522 AB are: PA 83.99° and a Sep of 15.89". For WDS 21139+2512, the PA was 108.17° and a Sep of 5.54". According to Gaia parallax data for these stars, it was concluded that these two systems are not gravitationally bound and are visual binary systems.

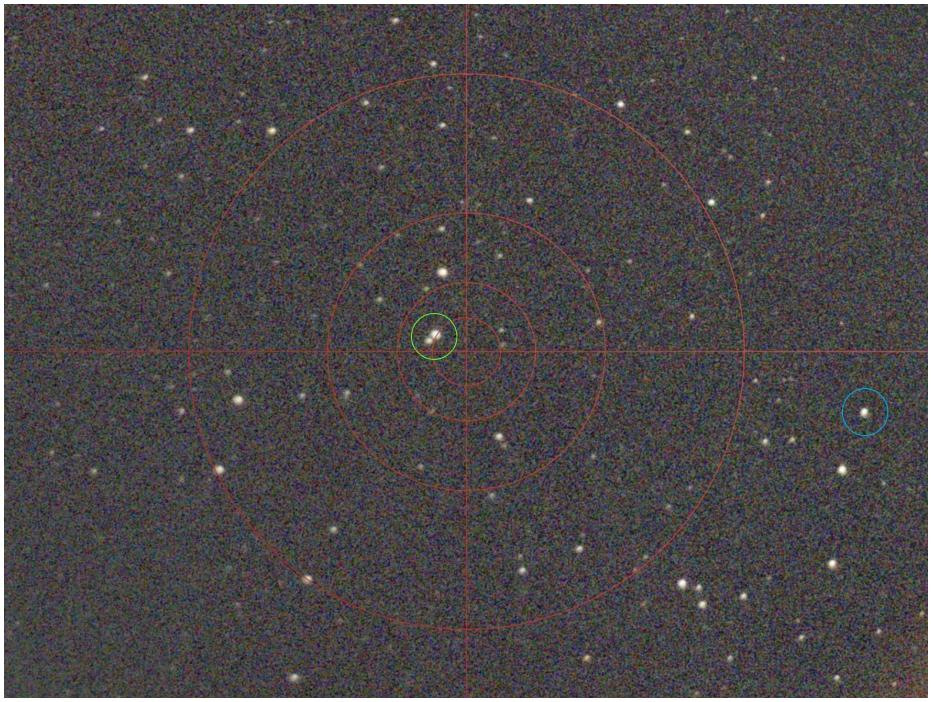

Figure 1: Photograph by Sanat Vidwans. WDS 21143+2522AB (green) and WDS 21139+2512 (blue), taken on July 29th at 22:01 PDT, 2022 near Big Finn Hill park, Kirkland, WA. The equipment used was a 130mm Newtonian reflector telescope with a 650mm focal length and a ZWO ASI224MC camera.

Introduction

The goal of this paper was to record the current position angle and separation of WDS 21143+2522 AB. According to *Stelle Doppie*, these systems are located within the Vulpecula constellation in the northern hemisphere, both with uncertain classifications. Current images of this system were taken on July 7th, 2022, and recorded. While reviewing the images, it was apparent that a secondary binary system, WDS 21139+2512, was within the telescope's field of view. Therefore, measurements of the secondary system's current position angle and separation were also recorded.

WDS 21143+2522AB, which has an RA of $21^h\ 14^m\ 18.37^s$ and a DEC of +25° 22' 15.3", was discovered by French astronomer Abel Pourteau in 1893 (Smith, 2012). The magnitude of the primary star (A) in this system is 10.10, and the secondary (B) has a magnitude of 11.90, with a Δmag of 1.8. The first measurements of this system are recorded as having a separation (ρ) of 16.8", with a position angle (θ) of 92°. The most recent astrometric measurements of this system were in 2015, which recorded a separation (ρ) of 15.9" and a position angle (θ) of 84°. In total, there have been 13 observations of the primary and secondary (AB) stars in this system. Note: The WDS 21143+2522 has a tertiary (C) component that could not have measurements taken due to limitations in the telescope resolution and the measuring software, AstroImageJ, which meant that the C component was hidden behind the A component.

WDS 21139+2512 was discovered later in 1898, also by Pourteau (Smith, 2012) and is located at RA $21^h\ 13^m\ 51.48^s$ and DEC +25° 11' 44.4". Like the other system, it was last observed in 2015. The magnitude of the primary star (A) is 11.28 and the secondary is 13.90, with a Δmag of 2.62. The initial measurements of this system are recorded as a separation (ρ) of 7.7" with a position angle (θ) of 104°. The most recent astrometric measurements of this system were recorded with a separation (ρ) of 5.8" and a position angle (θ) of 108°. In total, there have been 11 observations of the primary and secondary (AB) stars in this system.

Equipment and Procedure

WDS 21143+2522 AB was selected using the Stelle Doppie Database Selection Tool using the below parameters.

Table 1: Parameters used to select WDS 21143+2522 AB in the StelleDoppe Database Selection Tool.

	RA	Dec	Pri. Mag	Sec. Mag	Δmag	Sep.	Last Obs
Min	$14^h\ 00^m\ 00^s$	-90° 00' 00"	10	10	<3	5	2015
Max	$23^h\ 00^m\ 00^s$	+90° 00' 00"	12	14		10	

Once the original candidate was selected, an observation request was submitted using the Las Cumbres Observatory Global Telescope (LCOGT), a global network of telescopes that supports science and education. The images were taken on July 7th, 2022 between 01:54:35 and 02:00:23 UTC by an LCOGT observation node located at the Teide observatory in Tenerife, Canary Islands, Spain (a similar observational node is shown in Figure 2). A total of ten images with a 10-sec exposure time were requested, using a Bessel-V (visible) filter, on one of the site's two, 0.4-m telescopes with an SBIG STL-6303 CCD camera. The initial target of the images was WDS 21143+2522 which is located at a RA of $21^h\ 14^m\ 18.27^s$, and a DEC of +25º 22' 15.3". However, due to the field of view of the telescope, it was discovered that WDS 21139+2512 was also within the images available.

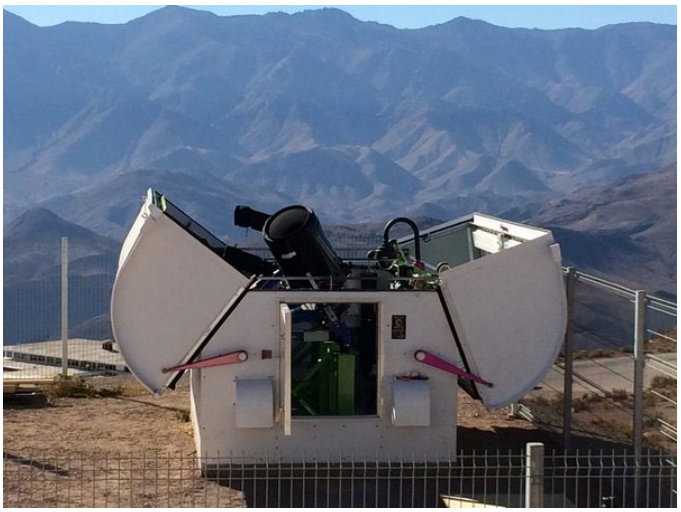

Figure *2. A 0.4-m instrument is similar to the one at the Teide observatory used for imaging - this particular instrument is located at a Las Cumbres node at the Cerro Tololo observatory in Chile.*

Fits files of the images were expanded and analyzed with the image analysis software, AstroImageJ, to determine the current position angle and separation of the stars within these systems. Astrometric measurements of both systems were taken using the provided measurement tool (Figure 3). Historical data for the position angle and separation was requested from Dr. Rachel Matson at the United States Naval Observatory (USNO) and compared to current astrometric measurements. From this, two historical data plots were made for each system. Finally, on VizieR, data from Gaia DR3 was found for the A and B components for WDS 21143+2522, and the A and B components for WDS 21139+2512.

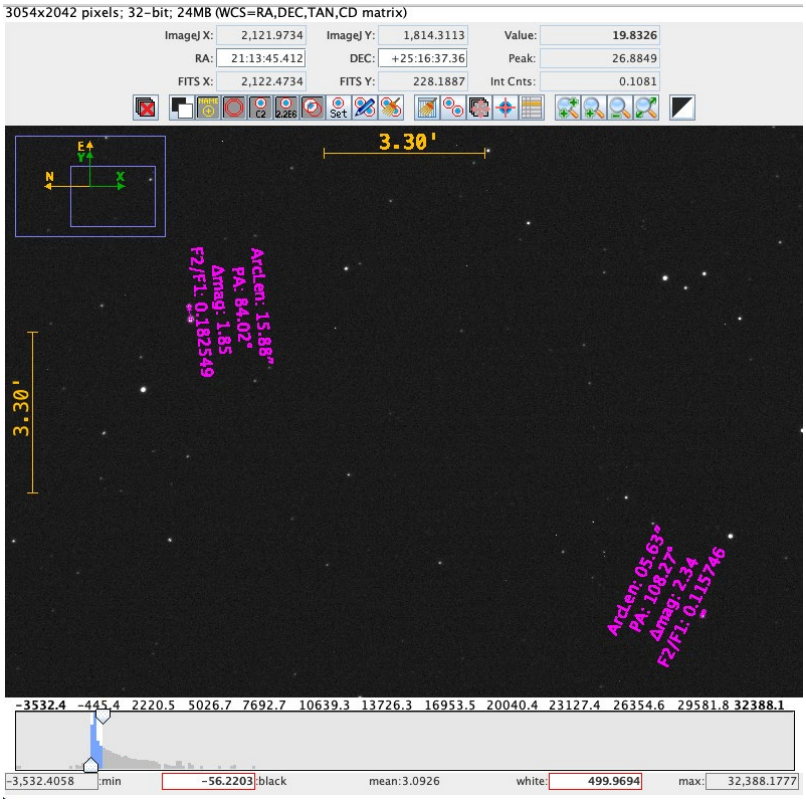

Figure 3. *A screenshot of the AstroimageJ interface with the first of the ten images. Measurements of both star systems have been taken and the data is displayed as shown.*

Historical data obtained from the USNO for WDS 21143+2522 AB (left) and WDS 21139+2512 (right), is shown in Table 2.

Table 2: Historical data (left) WDS 21143+2522 AB. (right) WDS 21139+2512. Separation (ρ) is measured in arcseconds, position angle is measured in (θ) degrees.

WDS 21143+2522 AB		
Epoch	Sep "	PA °
1893.70	16.79	92.0
1894.71	16.67	92.0
1897.73	15.95	91.5
1898.70	17.20	93.4
1982.90	15.88	87.0
2000.40	15.99	85.1
2001.70	16.03	85.3
2005.75	15.85	85.0
2009.88	15.99	85.9
2012.74	15.90	84.5
2013.65	15.90	84.5
2014.66	15.92	84.4
2014.79	15.90	84.4
2015.00	15.90	84.4

WDS 21139+2512		
Epoch	Sep "	PA °
1898.70	7.70	103.90
1982.90	6.13	116.70
2000.51	6.04	107.30
2001.70	6.03	107.00
2009.88	5.52	110.62
2012.76	5.71	107.95
2013.54	5.82	107.86
2013.64	5.79	107.94
2014.67	5.78	107.96
2015.00	5.81	107.96
2015.71	5.80	107.92

Results

Current measurements representing the separation and position angle between the A and B components are displayed (Table 3). Measurements of ten images from both sets, for each system, are shown. The mean of the standard deviation for each set of images was also calculated to determine the variability and precision of the average.

Table 3: Data for (left) WDS 21143+2522, (right) WDS 21139+2512. Separation (ρ) is measured in arcseconds, with position angle measured in (θ) degrees, The Average, Standard Deviation, and Standard Error of the Mean have been calculated.

WDS 21143+2522 AB		
Image	Sep "	PA °
1	15.88	83.96
2	15.87	84.03
3	15.90	84.08
4	15.89	84.00
5	15.89	83.89
6	15.90	83.94
7	15.91	84.01
8	15.91	83.95
9	15.89	84.01
10	15.84	84.04
Average	**15.89**	**83.99**
SD	**0.06**	**0.02**
SEM	**0.02**	**0.01**

WDS 21139+2512		
Image	Sep "	PA °
1	5.63	108.27
2	5.68	107.49
3	5.60	108.27
4	5.56	108.05
5	5.65	108.40
6	5.60	107.91
7	5.35	108.39
8	5.14	109.35
9	5.63	107.98
10	5.60	107.60
Average	**5.54**	**108.17**
SD	**0.16**	**0.52**
SEM	**0.05**	**0.16**

Discussion

In the following graphs (Figures 4 & 5) the red circle at (0,0) represents the A component, the gray triangles represent the historic relative position of the B component, and the green triangles represent the observed position of the B component according to our newest measurement. Older historical data points are a light shade of gray, and newer points are darker.

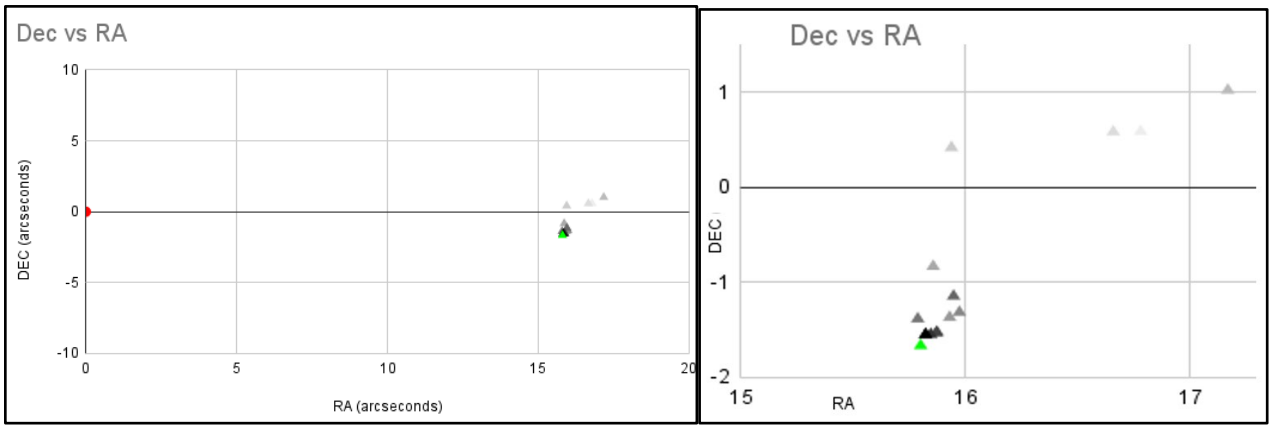

Figure 4. Historical data for WDS 21143+2522 AB. (left) Shows the A component relative to the B component. (right) Shows a zoomed-in representation of the graph, note that the RA marking begins with 15. The saturation of the gray triangle on historical points is a sliding scale, light for the oldest measurements, and darker for the most recent, except for the new data point, which is marked with green.

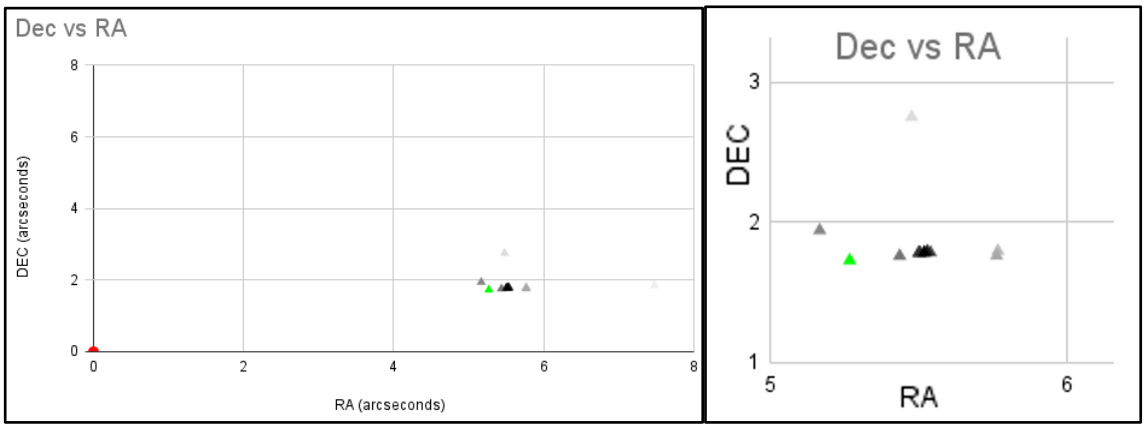

Figure 5. Historical data for WDS 21139+2512. (left) Shows the A component relative to the B component. (right) Shows a zoomed-in representation of the graph, note that the RA marking begins with 5 and DEC markings begin with 1. The saturation of the gray triangle on historical points is a sliding scale, light for the oldest measurements, and darker for the most recent, except for the new data point, which is marked with green.

From VizieR, data from Gaia DR3 was found for the A and B components for WDS 21143+2522, and the A and B components for WDS 21139+2512. This is displayed in table 4 below.

Table 4. WDS 21143+2522 AB Gaia DR3

Component	Parallax (mas)	PM RA (mas/yr)	PM Dec (mas/yr)
A	3.11 ± 0.02	-9.53 ± 0.02	-24.65 ± 0.01
B	2.17 ± 0.02	-16.36 ± 0.02	-9.00 ± 0.01

From the parallax values, WDS 21143+2522 A is 321.048 parsecs from Earth, and WDS 21143+2522 B is 459.812 parsecs from Earth. Based on these values WDS 21143+2522 A and WDS 21143+2522 B have a spatial separation of 28,622,129.57 AU. According to Harshaw (2018), very few binaries have separations that are more than 3,000 AU, and most are closer than 1,000 AU. He also states that two stars separated by one parsec are probably too far to be gravitationally bound, even if they are massive. Since this system has a separation of tens of millions of AU, it is exceedingly unlikely that these two stars are gravitationally bound.

For WDS 21143+2522 AB, the proper motion values are -9.53 ± 0.02 in RA and -24.65 ± 0.01 in DEC for the A component and -16.36 ± 0.02 in RA and -9.00 ± 0.01 in DEC for the B component. These values do not show any similarities, especially for the proper motion values in the DEC axis (Table 4). In the historical data and graph of such data, no defined orbital trajectory is shown. The separation remains variable, but is generally decreasing over time. The position angle also shows a trend down over time, and is less variable then the separation.

Table 5. WDS 21139+2512 Gaia DR3

Component	Parallax (mas)	PM RA (mas/yr)	PM Dec (mas/yr)
A	2.56 ± 0.13	11.85 ± 0.1	-12.30 ± 0.10
B	0.84 ± 0.02	-3.6 ± 0.02	-8.89 ± 0.01

Using the parallax values, WDS 21139+2512 A is 390.244 parsecs from Earth, and WDS 21139+2512 B is 1197.031 parsecs from Earth. From this, WDS 21139+2512 A and WDS 21139+2512 B has a spatial separation of 166,411,764.2 AU. This distance is more than five times greater than WDS 21143+2522, which has been determined to be almost certainly not gravitationally bound.

For WDS 21139+2512, the proper motion values are 11.85 ± 0.1 in RA and -12.30 ± 0.10 in DEC for the A component and, -3.6 ± 0.02 in RA and -8.89 ± 0.01 in DEC for the B component. They also do not show any similarities. For the proper motion in the RA axis, the two stars are traveling in opposite directions. In the historical data the separation decreases over time, this is shown in the historical data graph as the points get closer to 0,0. The position angle steadily increases over time except for one outlier observation is 1982. By purely observing the graph, this line may be considered as an orbital trend. However, from the parallax values, this simply means WDS 21139+2512 B is passing behind WDS 21139+2512 A as the former is more then four times further from Earth (Table 5).

Conclusions

Using the Las Cumbres Observatory portal and the Teide observatory in Tenerife, Spain, images were taken and astrometric data were collected on two separate binary star systems, WDS 21143+2522 AB and WDS 21139+2512. Historical data were then requested from the United States Naval Observatory and compared to the new astrometric measurements. For WDS 21143+2522 AB, the historical chart does not show a clear orbital trajectory. For WDS 21139+2512, the historical chart shows a straight line, which is subject to interpretation. However, the difference in parallax values from Gaia DR3 for both systems, WDS 21139+2512 and WDS 21143+2522 AB, are evidence that it is extremely unlikely that they are gravitationally bound and are simply visual binary systems.

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References

Collins, K. A., Kielkopf, J. F., Stassun, K. G., & Hessman, F. V. (2017). ASTROIMAGEJ: Image Processing and Photometric Extraction for ULTRA-PRECISE ASTRONOMICAL Light Curves. The Astronomical Journal, 153(2), 77–89. https://doi.org/10.3847/1538-3881/153/2/77

Gaia DR3 content - Gaia - Cosmos. (2022). GAIA EARLY DATA RELEASE 3 (GAIA DR3). Retrieved August 3, 2022, from https://www.cosmos.esa.int/web/gaia/earlydr3

Harshaw, R. (2018). Gaia DR2 and the Washington Double Star Catalog: A tale of two databases. *Journal of Double Star Observations*, *14*(4), 734-740. http://www.jdso.org/volume14/number4/Harshaw_734_740.pdf

Smith, F. (2012, August 1). The Double Stars of Abel Pourteau. Journal of Double Star Observations. Retrieved July 30, 2022, from http://www.jdso.org/volume8/number4/Smith_v8_p243.pdf

Stellar Distance and Parallax Calculator • Astronomy • Online Unit Converters. (2022). TC Unit Converter. Retrieved August 3, 2022, from https://www.translatorscafe.com/unit-converter/en-US/calculator/parallax-distance/?star=Arcturus

Stelle Doppie - Double Star Database. (2022). Stelle Doppie. Retrieved August 3, 2022, from https://www.stelledoppie.it/index2.php

Teide | Las Cumbres Observatory. (2022). Las Cumbres Observatory. Retrieved August 3, 2022, from https://lco.global/observatory/sites/teide/

VizieR. (2022). VizieR. Retrieved August 3, 2022, from https://vizier.cds.unistra.fr/viz-bin/VizieR