Astrometric Measurement of WDS 02462-5403 A and B

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Abstract: The nature of WDS 02462-5403 A and B were investigated. The A and B stars were measured by Las Cumbres Observatory Network telescopes. The separation measured during our investigation was 8.401″ and the position angle was 164.624°.

Introduction

Overview:

The objective of this investigation of WDS 02462-5403 was to attain measurements of the current separation and position angle of the stars to add to the minimal historical database. Historical measurements in 1998 and 1999 of WDS 02462-5403 by the Two Micron All-Sky Survey (2MASS) and the Sloan Digital Sky Survey (SDSS) have determined the position angle and separation of these double stars, but no other information has been recorded. A GAIA survey of WDS 02462-5403 in 2015 provided an additional data point to utilize. Utilising observatories owned and operated by the Las Cumbres Observatory in addition to private telescopes owned and operated by ELTHAM College of Education in Victoria, Australia, data on the stellar properties of WDS 02462-5043 was obtained. Additionally, historical data from the 2MASS Sky Survey and Sloan Digital Sky Survey was provided by Dr Brian Mason of the U.S. Naval Observatory.

Target:

Designation:

– WDS 02462-5403, UC 804

Coordinates:

– RA: 02^{H} 46^{M} 9.13^{S}, DEC: -54° 03’ 13.3”

Information and Interest:

WDS 02462-5403 is a suspected physical double in the constellation Horologium first discovered in 1998 by the Two Micron All-Sky Survey (2MASS). WDS 02462-5403 has also been imaged as part of the Sloan Digital Sky Survey (SDSS) (Figure 1.), making that the second observation out of two historical observations. Stelle Doppie’s data for the stars shows a last recorded magnitude of 12.6 and 12.9 for the A and B stars and a separation of 8.4 arcseconds, separating 0.1 arcseconds in one year. However, the estimation of the stars relative movements is within the margin for error and could be distorted by atmospheric seeing. While there is insufficient data to determine an orbital trajectory from these two observations the stars have been noted as physical doubles (Stelle Doppie, 1999). Our research backs up this conclusion due to the distance between WDS 02462-5403 A and B and proper motion data attained from GAIA’s DR2 survey

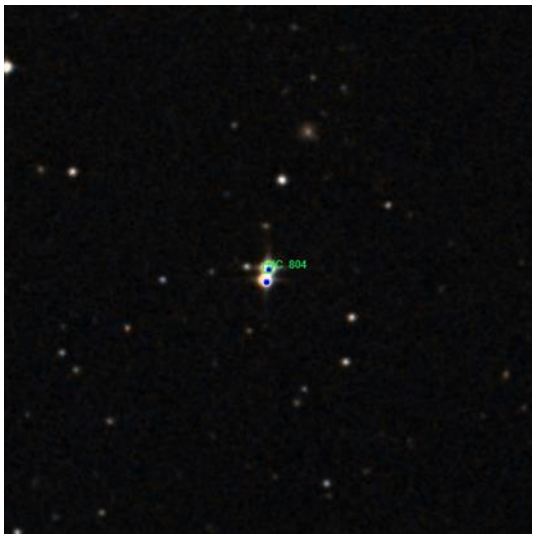

Figure 1: WDS 02462-5403 AB as imaged by the Sloan Digital Sky Survey

Equipment

Observations were made using the Las Cumbres Observatory Network, utilizing the Meade LX200 16” (0.4m) telescopes equipped with SBIG STL-6303

Received November 19, 2020

CCD cameras giving a field of view of 29.2 x 19.5 arcminutes. All data was captured from the Siding Springs Observatory in New South Wales, Australia, the South African Astronomical Observatory in Sutherland, South Africa and the Cerro Tololo Observatory in the Coquimbo Region, Chile.

Methods

Candidates for research were selected by utilizing the Gaia Double Star Catalogue Selection Tool (GDS) provided to the research team by Dave Rowe (2020) GDS allowed for faster access to both the WDS and GAIA databases.

Images were captured with exposure times ranging from 0.5, 0.75, 1.0, 1.5 and 2 seconds which the LCO calibrated in their backend systems using dark, bias, and flat frames. Imaging sessions were completed on the 1st, 7th, and the 18th of October 2020. Following the acquisition of the images, AstroImageJ was utilized to plate-solve the image and compare our data to historical observations. The stars were identified as the A and B star of WDS 02462-5403, and the separation of the stars was determined by measuring the distance between the centre of both stars. The results were recorded in arcseconds. This data was then exported into the Plot Tool provided by Richard Harshaw (2020) and merged with pre-existing historical observations of WDS 02462-5403. Utilizing this document and combining the 28 data points obtained in this survey with historical measurements provided by Dr Brian Mason, the separation and position angle of the double stars were calculated. In addition, Plot Tool was used with values attained from the GAIA DR2, to determine the parallax, luminosity, mass, radius, and stellar class of both stars.

Results

Table 1 shows the mean recorded value of arcseconds and position angle from each major observation in addition to their standard deviations. Standard deviations cannot be displayed for historical observations due to limited datasets.

Table 2 shows the average of all data points recording separation and position angle in addition to the standard deviation and standard error.

Table 3 shows all measurements from this investigation taken from the LCO Network including outliers.

Table 4 below provides data on the stellar properties from Gaia DR2 and the Plot Tool. The weighted (median between highest and lowest estimate) distance of the system to Earth and separation between the A and B stars are provided.

Figure 2 shows the changes in position angle and separation over time. The blue data point represents the average position of WDS 02462-5403 as recorded by the LCO during this investigation. The historical data points from 2MASS, SDSS and GAIA are also depicted to demonstrate movement over time.

Discussion

The original aims of the investigation were to obtain position angle and separation measurements of WDS 02462-5403. Information collected utilizing the LCO Network combined with historical data from 2MASS, SDSS and GAIA, as shown in Figure 2 and Table 1, displays that the change in position angle was approximately 0.0087° while the separation changed

Year of Observation	Recorded Separation(″)	Standard Deviation(″)	Recorded Position Angle (°)	Standard Deviation (°)
Mean 1998.746	8.337	n/a	164.713	n/a
Mean 1999.820	8.362	n/a	164.717	n/a
Mean 2020.789	8.401	0.089	164.624	1.174

Table 1: Mean separation and position angle of WDS 02462-5403 from all historical observations combined with standard deviation.

Year of Observation	Recorded Separation(″)	Standard Deviation(″)	Recorded Position Angle (°)	Standard Deviation (°)
2020.789	8.401	0.089	164.624	1.174

Table 2: Mean of all separation and position angle data points from this investigation including standard deviation and standard error.

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Year of Observation	Separation (″)	Position Angle (°)
2020.778	8.357	160.978
2020.778	8.700	164.551
2020.778	8.503	165.898
2020.778	8.440	165.806
2020.778	8.486	163.408
2020.778	8.519	166.582
2020.778	8.506	164.423
2020.778	8.374	164.769
2020.778	8.300	164.221
2020.778	8.389	165.026
2020.778	8.348	165.010
2020.778	8.273	165.284
2020.778	8.351	161.444
2020.7992	8.339	165.460
2020.7992	8.359	164.961
2020.7992	8.278	165.480
2020.7992	8.355	165.010
2020.7992	8.406	164.081
2020.7992	8.336	164.268
2020.7992	8.417	165.506
2020.7992	8.394	164.591
2020.7992	8.347	164.177
2020.7992	8.415	165.248
2020.7992	8.438	164.816
2020.7992	8.447	163.984
2020.7992	8.356	165.297
2020.7992	8.403	164.415
2020.7992	8.500	164.323

Table 3: All data points from this investigation including outliers.

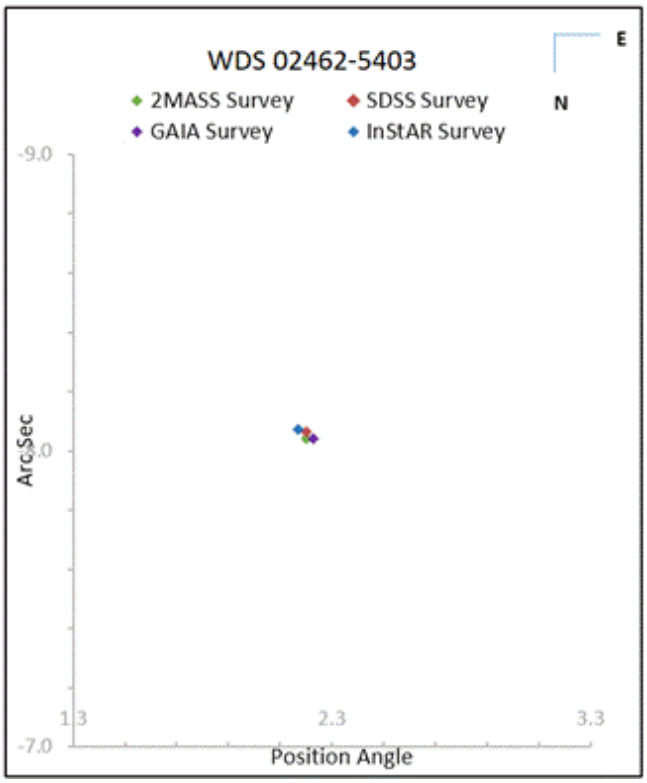

Figure 2: All data points from the historical survey in 1998 (2MASS Survey), 1999 (SDSS Survey), 2015 (GAIA) and the average data point from 2020 (InStAR Survey) data as plotted on a graph to demonstrate movement over time.

by an average of only 0.64 milliarcseconds. These measurements are within the margin of error that could be explained by atmospheric seeing or distortion of measurements due to delta magnitude, however, these findings are consistent with the data supplied by ESA's GAIA Data Release 2.

Additionally, data from ESA's GAIA Data Release

	WTD Distance (L.Y.)	WTD Separation	Stellar Class	Est Mass (M⊙)	Est Radius (R⊙)	Est Lum (L⊙)	Eff Temp (K)	Parallax (″)	Parallax Error
Star A	769±19	38,891	G-Class Main Sequence	0.8	0.730	0.464	5033	4.19	2%
Star B	769±16	38,891	K-Class Main Sequence	0.72	0.606	0.311	4898	4.27	2%

Table 4: Table summarising the stellar properties of WDS 02462-5403 A and B from Gaia DR2

2 allowed the inclusion of several important stellar properties of both stars. Using Plot Tool, to calculate raw data values from GAIA DR2, it was estimated that the A star in WDS 02462-5403 has a mean distance of 769±19LY with a parallax of 4.19 and an error of ±2%. The A star is a G-Class Main Sequence with a mass 0.8 M⊙ an estimated radius of 0.73 R⊙, a luminance of 0.464 L⊙ and an effective surface temperature of 5033K. The B star of WDS 02462-5403 has a mean distance 769±16LY with a parallax of 4.27 and an error of ±2%. The B star is a K-Class Main Sequence with a mass of 0.72 M⊙, an estimated radius of 0.606 R⊙ a luminance of 0.311 L⊙ and an effective surface temperature of 4898K.

Utilizing Plot Tool to calculate true separation through the parallax values supplied by GAIA DR2, both stars have been estimated to have a weighted separation, meaning the median value of both the largest and smallest separation estimates, of approximately 38,891AU (0.615 LY). Both stars are projected to have a 43% overlap in their distance estimates, suggesting that they are likely close enough to be a physical double, meaning while not bound to a common centre of mass, the two stars exert gravitational forces on one another that can affect their orbital paths around the galaxy. A separation of 0.615LY means that WDS 02462-5403 A and B are extremely unlikely to be a binary pair. If they were, they would have an orbital period of approximately 6,200,000 years ±20,000 years. However, based on the escape velocity equation seen below, the escape velocity of the stars if in a binary orbit with 38,891AU of separation would be 263m/s. A binary system with these properties would be highly unstable, and any passing star would likely disrupt the orbit and eject one or both stars.

$$v_e = \sqrt{\frac{2GM}{r}}$$

Table 3: All data points from this investigation including outliers.

Conclusion:

The results obtained using data from the LCO network, in addition to historical data from the 2MASS, SDSS and GAIA surveys, showed that the position angle of WDS 02642-5403 changed 0.087 degrees while the separation increased by 0.64 milliarcseconds over the last 22 years. Furthermore, data from the GAIA DR2 suggests that WDS 02462-5403 have a separation of approximately 0.615LY. This suggests two possible conclusions: either the two stars are too far apart to be gravitationally bound meaning they are not a physical double contrary to what is noted on Stelle Doppie but are optical doubles instead, or the two stars are physical doubles and may have an orbital period of approximately 6,200,000 years if binary, making it impossible to determine an orbit at this time.

While conclusive evidence as to the nature of the gravitational binding of stellar bodies in WDS 02462-5403 may not be currently possible to ascertain, this investigation has collected data that may help someday to determine its true nature.

Acknowledgements:

Thank you to Rachel Freed for supervising the production of the research paper and providing us with valuable feedback to improve it. Thank you to Richard Harshaw for providing us with the Plot Tool to interpret and understand our data in addition to data provided from the GAIA DR2 Survey. Thank you to Dr Brian Mason for providing us with historical data for the WDS 02462-5403 system to aid in our research. Thank you to Darren Smith for assisting in the writing of the research paper, providing us with valuable corrections for it. Thank you to Andrew Yen for providing us with useful information throughout the research process regarding our stars and how to understand our data in addition to access to telescopes at the ELTHAM College Observatory.

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