Astrometric Measurements of WDS 04263+1400

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Abstract: Using images taken on March 21 and March 29, 2021 with 0.4-meter telescopes from the Las Cumbres Observatory Global Telescope Network (LCOGT), the double star system WDS 04263+1400 was analyzed. It was calculated that the system had an average position angle of 243.45° and an average separation of 6.68″. These measurements were consistent with the previous measurements of WDS 04263+1400. Moreover, the data revealed that there is a potential tertiary star in the system, but it could not be confirmed. Based on proper motion and parallax data, it is highly likely that this is a physical pair.

Introduction

Classification of multiple star systems provides insights into stellar evolution by directly allowing for stellar mass calculations. This project provides new data to aid in the classification of a known double star system. A suitable candidate for observation was chosen from numerous systems using the following criteria: the stars had not been observed within the past five years, the stars were between 4 and 17 hours of right ascension, each star had a magnitude between 10 and 12 and a delta magnitude of 3 or less, the stars were at least 5 arc seconds apart, and the physical nature of the system was undetermined. Using Stelle Doppie (SD, 2010) and the Washington Double Star (WDS) catalog (Mason et al., 2001), WDS 04263+1400 (HJ 3256) was selected, which is in the constellation Taurus. The spectral types of the primary and secondary are K and G respectively, as reported in GAIA. The earliest observation of WDS 04263+1400 was reported in 1832 by John Herschel. Additional data was collected between 1905 and 2015. Historical data for WDS 04263+1400 was procured from Dr. Brian Mason at the United States Naval Observatory (USNO) and is presented in Table 1.

Date	Angular separation (arcsec)	Position angle (degrees)
1905.99	6.485	236.6
1910.08	6.536	243.2
1911.05	6.87	243.8
1933.0	6.70	238.8
1960.0	6	250
1998.88	6.63	242.3
2000.853	6.741	243.1
2010.052	6.78	243.2
2010.5	7.10	244.7
2012.9	6.739	243.36
2013.99	6.748	243.12
2014.909	6.751	243.14
2015.0	6.757	243.118

Table 1. Historical measurements of WDS 04263+1400

Methods and Observations

Two of the LCOGT's 0.4-meter telescopes, located in Haleakala, Hawaii and at the McDonald Observatory in Texas (see Figure 1), were used to observe this star. Ten images were taken on March 21, 2021, (BJD 2459295.73, Eastman, 2010) but only eight were usable (two having bad focus), and ten more were taken on March 29, 2021 (BJD 2459303.59). Each picture had a three second exposure time and used a clear filter. The resulting FITS files were then

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analyzed using AstroImageJ (Collins, 2017). See Figure 2.

Figure 1. LCOGT's McDonald (top) and Haleakala observatories (bottom)

The mean position angles and separations were taken from the 18 usable images. The PlotTool spreadsheet (Harshaw, 2020) was used to combine newly collected data with the historical data as well as the current GAIA data taken via Vizier. This was then used to plot the position of the stars on a Cartesian coordinate system and calculate the stars' spectral types and distances.

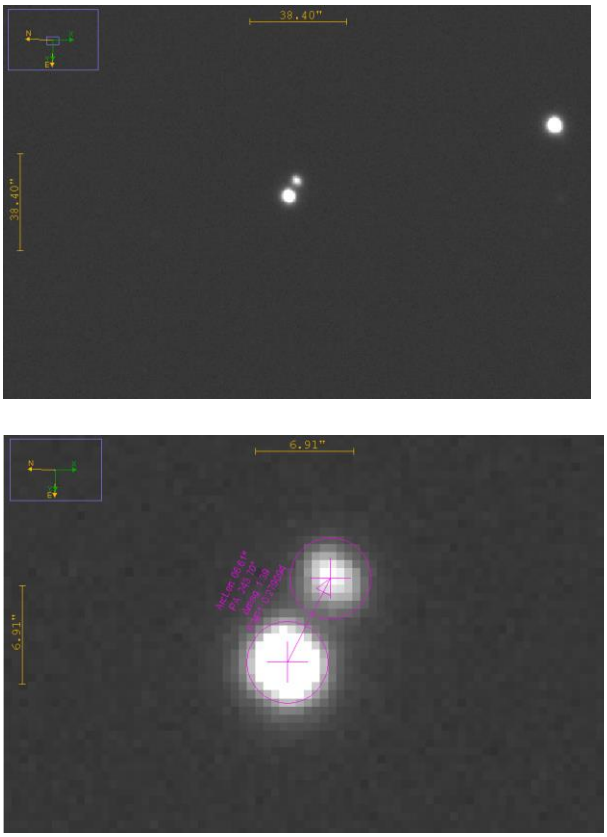

Figure 2. WDS 04263+1400 and zoomed-in sample measurement, both from AstroImageJ

Results

The mean separation of the stars in WDS 04263+1400 was measured to be $6.68'' \pm 0.014$, and the position angle of the secondary star was measured to be $243.45° \pm 0.11$. This data, along with standard deviations and the standard errors of the mean, is presented in Table 2.

	Separation, ρ(arcsec)	**Position Angle, θ(deg)**
Mean	6.68	243.45
Stan. Dev.	0.058	0.468
SEM	0.014	0.11

Table 2: Separation and position angle measurements for WDS 04263+1400

Additional parameters (from Harshaw's PlotTool and Gaia DR2) for the primary and secondary stars, are shown in Table 3.

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	Star A	Star B
Spectral Type	K	G
T_{eff} (K)	4200	5209
Mean distance (pc)	485	457
Luminosity ($L_{\odot}$)	22.1	5.3
Absolute magnitude	1.48	3.03

Table 3. WDS 04263+1400 parameters

A tertiary star was observed in several images (see Figure 3), but AstroImageJ gave inconsistent measurements for it as it was not resolvable.

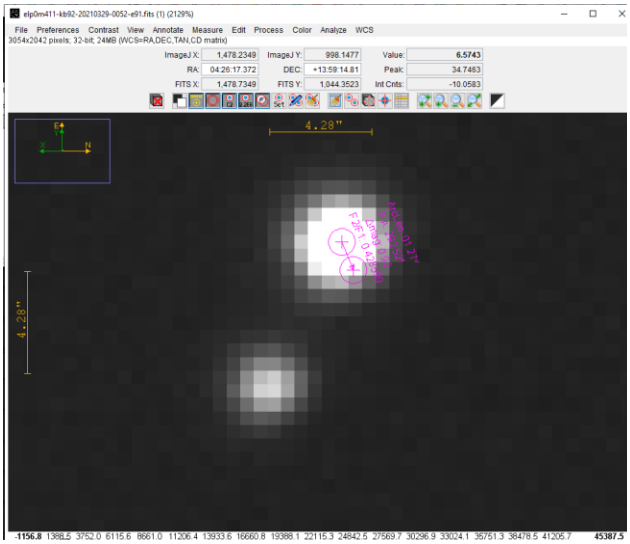

Figure 3. Tertiary star, in AstroImageJ

Discussion

The current measurements conform closely with the 11 previous measurements of WDS 04263+1400 taken from the WDS catalog (excluding questionable observations as marked in the WDS data); however, no measurable trend is clear that would distinguish between a common proper motion system and a true binary. Historical (in green) and new data (in red) are plotted in Figure 4.

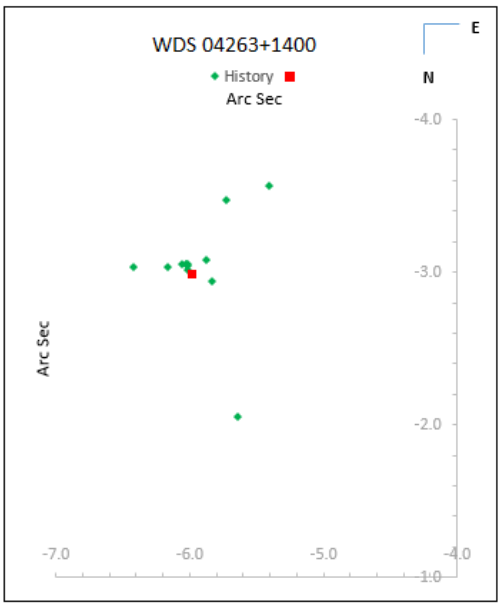

Figure 4. Historical (green) and new (red) data for WDS 04263+1400

The proper motions of the primary and secondary stars are shown in Table 3, and along with the almost identical parallaxes of 2.1564 mas for the primary and 2.1804 mas for the secondary indicate that the two share a common origin at the least. The Harshaw Statistical Value calculation (Harshaw 2014) of 0.0007 strongly suggests that the pair is physical. Using the measured angular separation of the primary and secondary stars and the mean of the two Gaia parallaxes for them the physical separation of the two stars was found to be 3074 AU (0.049 ly). This relatively close separation, combined with the other data, point to high likelihood of the pair being a physical double.

	Primary	Secondary
RA	1.654	1.773
Dec	-9.904	-9.880
Total	10.041	10.038

Table 3. Proper motion (from Gaia) (mas/yr)

Interestingly, GAIA DR3 records a third star at 04 26 16.846 +13 59 04.363 (Gaia EDR3 #3310773001797615488), between the primary

and secondary stars, at a calculated separation of 4.56 arcsec from the primary. It has a G magnitude of 21.049, but Gaia measures no parallax or proper motion for it, so it cannot be determined to be part of the WDS04263+1400 system. See Figure 5.

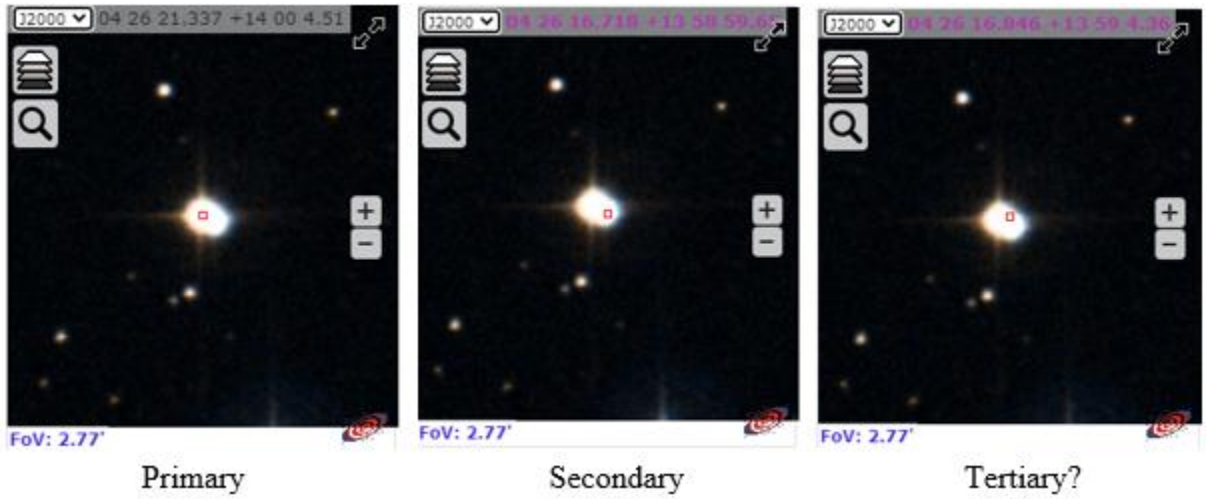

Figure 5. Primary, secondary, and possible tertiary stars in WDS 04263+1400. Centroids marked in red.

Conclusion

The data collected for WDS 04263+1400 star system fits well with the measurements that were previously made. However, there is still not enough information to determine if the system is binary. It will require further measurements of the position angle and separation to track the system's movement and reach a conclusion about its nature. As for the possible tertiary star, a larger aperture telescope may be able to resolve the star and discern if it is, in fact, part of the WDS 04263+1400 system. Additionally, WDS 04263+1400 is an excellent candidate for Speckle Interferometric study.

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References

Collins, (2017), https://arxiv.org/abs/1701.04817

Eastman, Jason, Publications of the Astronomical Society of the Pacific, Volume 122, Issue 894, pp. 935 (2010).

Harshaw, R. (2020). Using Plot Tool 3.19 to Generate Graphical Representations of the Historical Measurement Data. *JDSO* Vol 16 No 4.

Harshaw, R. (2014). Another Statistical Tool for Evaluating Binary Stars. *JDSO* Vol 10 No 1.

Mason, B.D., Wycoff, G.L., Hartkopf, W.I., Douglass, G.G. and Worley, C.E., 2001, US Naval Observatory Double Star CD-ROM. I. The Washington Double Star Catalog Astronomical Journal, Volume 122, Issue 6, pp. 3466-3471. http://www.astro.gsu.edu/wds/)

Stellarium Astronomy Software. Version 0.18.1 (n.d.). http://stellarium.org/

Stelle Doppie - Double Star Database, Gianluca Sordiglioni. http://www.stelledoppie.it/index2.php