Measurements of WDS 20310-2700 and WDS 20313-2707

Tyler D. Scott[1], Sarah Grace Bogle[1], Kathryn M. Boeckers[1]
[1] Grace College, Winona Lake, Indiana; scottt@grace.edu

Abstract

We conducted a study on two double star systems, WDS 20310-2700 (DAM 1042) and WDS 20313-2707 (SKF 2086), using the Las Cumbres Observatory (LCO) global telescope network. The goal of the study was to determine separation and position angles of the double stars and possibly determine whether the systems are gravitationally bound. Our separation and position angle for WDS 20310-2700 were $10.73 \pm 0.03''$ and $1.78.9 \pm 0.22°$, respectively. Our separation and position angle for WDS 20313-2707 were $6.84 \pm 0.11''$ and $303.9 \pm 0.56°$, respectively. Future observations are required to establish whether these systems are binary or not.

1. Introduction

To identify interesting star systems to study, we searched the Stelle Doppie database (Sordiglioni, 2023), looking for double stars whose nature was "uncertain." We focused on stars with separation between 5-15″ and those that had not been observed since 2015. We also looked for systems with a primary star magnitude brighter than 13 and a magnitude difference between primary and secondary less than 3.

As a result of this search, we decided to observe and analyze WDS 20310-2700. The primary star (Gaia Designation 6799650892560759040) is located at a right ascension of 20h 31m 02.72s and declination of -27° 00′ 27.93″ and has a G-band mean magnitude of 12.6 (Gaia Collaboration, 2023). The secondary star (Gaia Designation 6799750892560757760) is located a right ascension of 20h 31m 0274s and declination of -27° 00′ 38.73″ and has a G-band mean magnitude of 13.6 (Gaia Collaboration, 2023). The system is located in the constellation Capricornus. This system was first observed in 1998 (DENIS Consortium, 2003) and last observed in 2000.

After taking images of this system, however, we found that the field of view of the images included a second double star system, WDS 20313-2707. This system was first observed in 1977 (Skiff, 2014) and last observed in 2016 (El-Badry et. al., 2021). Also in the constellation Capricornus, the primary star (Gaia Designation 6799737354823802368) is located at a right ascension of 20h 31m 20.31s and declination of -27° 07′ 11.57″ and has a G-band magnitude of 9.9 (Gaia Collaboration, 2023). The secondary star (Gaia Designation 6799737354823803648) is located at a right ascension of 20h 31m 19.88 s and declination of -27° 07′ 07.39″ and has a G-band magnitude of 13.8 (Gaia Collaboration, 2023). Therefore, this paper will include an analysis of both systems.

2. Equipment and Methods

We used the Las Cumbres Observatory global telescope network (LCO) to capture 10 images of these stars. Specifically, a 0.4-m telescope at the Cerro Tololo Observatory in Chile with a SBIG STL-6303 CCD was used with a V-band filter on 24 October, 2023 (2023.81) between 23:54:09 and 23:58:29 UTC. Image reduction was done by LCO using the BANZAI pipeline. Each image had a 10-s exposure time.

To analyze the images, we used Afterglow Workbench (Afterglow Access, 2023) to determine separation in arcseconds and position angle E of N. Two screenshots of the measurements are shown in Figure 1.

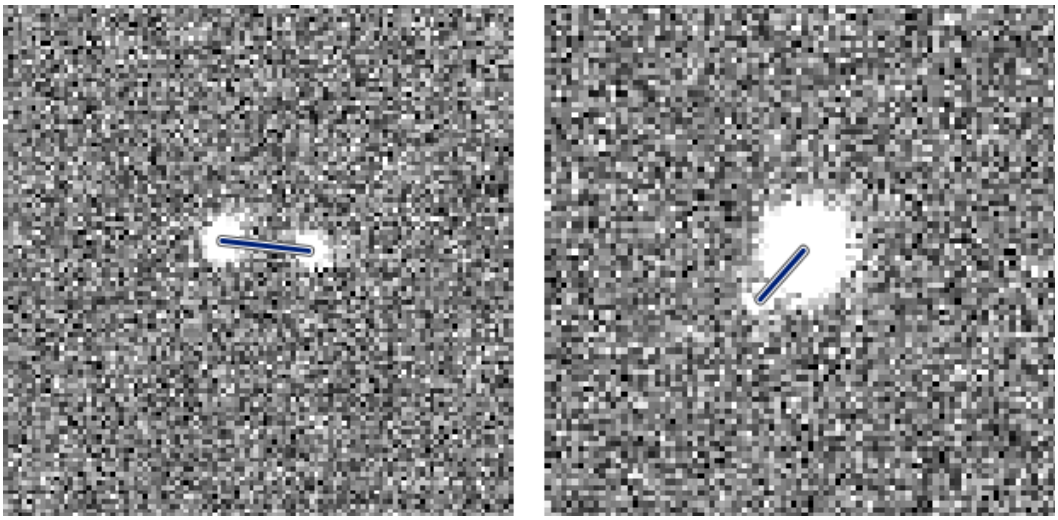

Figure 1: Afterglow Workbench measurement of WDS 20310-2700 (left) and WDS 20313-2707 (right)

We obtained parallax, proper motion, and magnitude data from the Gaia data release 3 (Gaia Collaboration, 2023). We obtained historical separation and angle data directly from the United States Naval Observatory (USNO).

3. Data

In Table 1, we include the measurements of separation in arcseconds and position angle in degrees for each of our 10 images of WDS 20310-2700. The table also includes the average values, the standard deviation, and the standard error of the mean for both separation and position angle.

Table 1: Current measurements and calculations of separation and position angle of WDS 20310-2700 (DAM 1042).

File Name	Sep (arcsec)	PA (deg)
lsc0m409-kb98-20231024-0057-e91.fits.fz	10.72	178.8
lsc0m409-kb98-20231024-0058-e91.fits.fz	10.84	179.1
lsc0m409-kb98-20231024-0059-e91.fits.fz	10.57	179.6
lsc0m409-kb98-20231024-0060-e91.fits.fz	10.67	178.5
lsc0m409-kb98-20231024-0061-e91.fits.fz	10.61	178.9
lsc0m409-kb98-20231024-0062-e91.fits.fz	10.78	177.7
lsc0m409-kb98-20231024-0063-e91.fits.fz	10.79	180.2
lsc0m409-kb98-20231024-0064-e91.fits.fz	10.90	178.7
lsc0m409-kb98-20231024-0065-e91.fits.fz	10.79	179.1
lsc0m409-kb98-20231024-0066-e91.fits.fz	10.66	178.2
Average	**10.73**	**178.9**
Std. Dev.	**0.10**	**0.69**
Std. Err. of Mean	**0.03**	**0.22**

In Table 2, we include the measurements of separation in arcseconds and position angle in degrees for each of our 10 images of WDS 20313-2707. The table also includes the average values, the standard deviation, and the standard error of the mean for both separation and position angle.

Table 2: Current measurements and calculations of separation and position angle of WDS 20313-2707 (SKF 2086).

File Name	Sep (arcsec)	PA (deg)
lsc0m409-kb98-20231024-0057-e91.fits.fz	6.77	303.9
lsc0m409-kb98-20231024-0058-e91.fits.fz	6.46	305.1
lsc0m409-kb98-20231024-0059-e91.fits.fz	7.02	305.6
lsc0m409-kb98-20231024-0060-e91.fits.fz	6.57	302.7
lsc0m409-kb98-20231024-0061-e91.fits.fz	7.01	302.7
lsc0m409-kb98-20231024-0062-e91.fits.fz	7.54	302.4
lsc0m409-kb98-20231024-0063-e91.fits.fz	6.97	306.5
lsc0m409-kb98-20231024-0064-e91.fits.fz	6.53	305.2
lsc0m409-kb98-20231024-0065-e91.fits.fz	7.11	304.1
lsc0m409-kb98-20231024-0066-e91.fits.fz	6.43	300.7
Average	**6.84**	**303.9**
Std. Dev.	**0.35**	**1.76**
Std. Err. of Mean	**0.11**	**0.56**

4. Discussion

To get the bigger picture of these two star systems, we have obtained historical data from USNO. These data are shown in Tables 3 & 4.

Table 3: Historical Separation and Position Angle Data from the USNO and the current study for WDS 20310-2700 (DAM 1042).

Date	Sep. (arcsec)	PA (deg)
1998.7258	10.84	178.7
1998.7366	10.82	178.7
1998.74	10.83	178.7
1999.50	10.814	178.5
1999.52	10.80	178.6
2000.0	10.76	178.6
2023.81	10.734	178.88

Table 4: Historical Separation and Position Angle Data from the USNO and the current study for WDS 20313-2707 (SKF 2086).

Date	Sep. (arcsec)	PA (deg)
1977.67	7.99	306.8
1999.50	7.060	305.8
1999.52	7.07	305.7
2010.5	6.88	303.4
2015.0	7.091	305.987
2015.5	7.08885	305.984
2016.0	7.08945	305.98
2023.81	6.84	303.9

The separation and position angle values found in this study are similar to the historical data. We converted the separation ρ and position angle θ to right ascension (RA) and declination (Dec) to rectangular coordinates with the following equations:

$$\mathrm{RA} = \rho \sin\theta$$

$$\mathrm{Dec} = -\rho \cos\theta$$

The results for WDS 20310-2700 are shown in Figure 2. While the USNO data included six data points (shown in Table 3). The data do not give us enough information to calculate an orbit. We only have 25 years of observations for this star system.

The results for WDS 20313-2707 are shown in Figure 3. The USNO data included seven data points. While there is more data and a longer time interval (46 years), they do not show a trend that can be fit to an orbit.

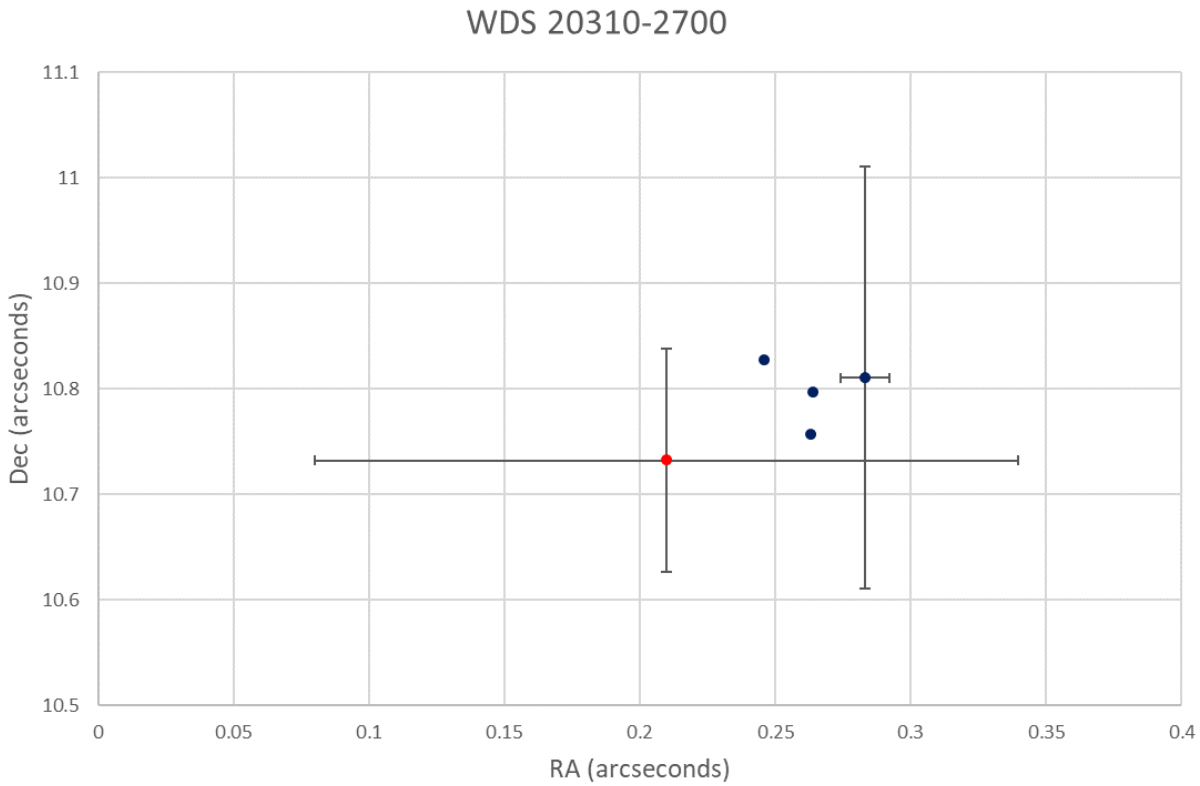

Figure 2: Plot of historical data (blue) and our observation (red) for WDS 20310-2700. The separation and position angle have been converted to right ascension and declination coordinates. Error bars are included when available.

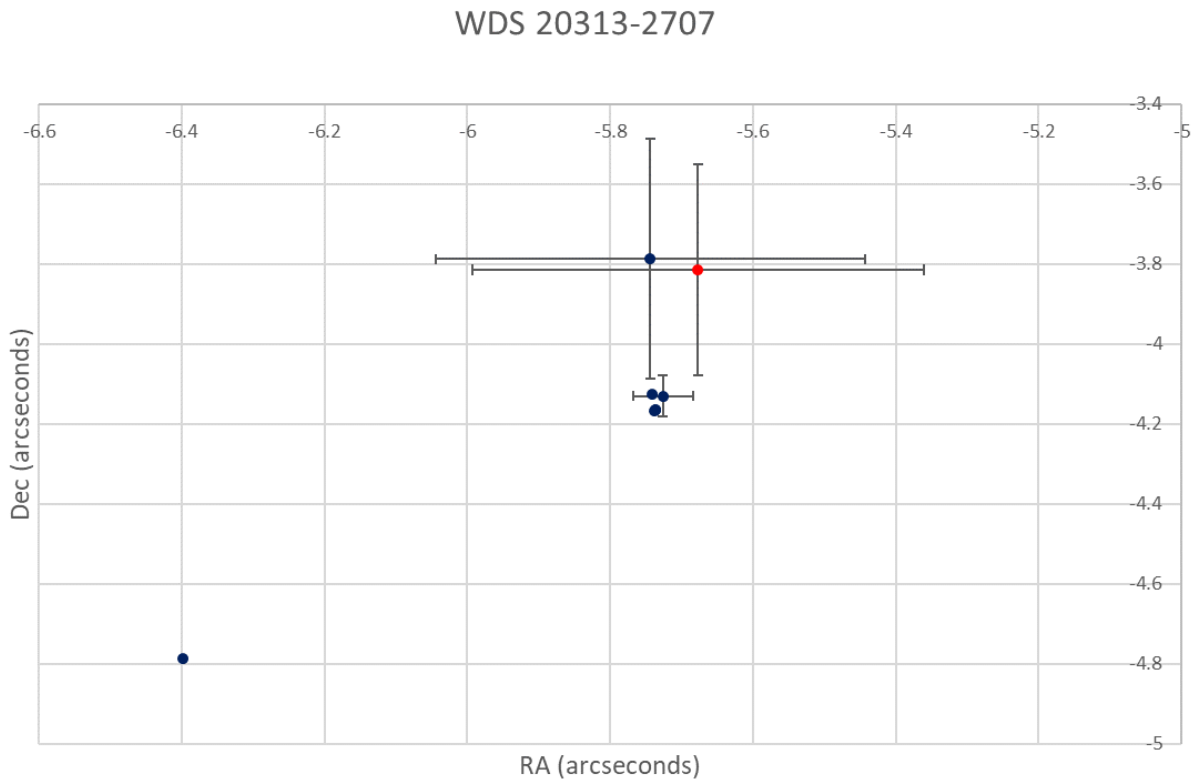

Figure 3: Plot of historical data (blue) and our observation (red) of WDS 20313-2707. The separation and position angle have been converted to right ascension and declination coordinates. Error bars are included when available.

Since an orbit cannot be calculated, an important question is whether the two stars are even near each other. Therefore, parallax and proper motion data were obtained from Gaia data release 3. In Tables 5 & 6, parallax data were used to calculate a distance to the stars using the equation $D = 1/\theta$, where D is the distance to the star in parsecs and θ is the parallax in arcseconds.

Table 5: Parallax from Gaia Data Release 3 with calculated distance for WDS 20310-2700.

Star	Parallax (mas)	Distance (pc)
Primary	1.594 ± 0.016	627.2 ± 6.1
Secondary	1.545 ± 0.016	647.2 ± 6.6

Table 6: Parallax from Gaia Data Release 3 with calculated distance for WDS 20313-2707.

Star	Parallax (mas)	Distance (pc)
Primary	9.31 ± 0.17	107.4 ± 1.9
Secondary	9.243 ± 0.018	108.2 ± 0.2

The stars of WDS 20313-2707 are very near each other. Distance to the stars calculated by parallaxes are within the uncertainty range of each other. The stars of WDS 20310-2700 are much further apart, around 20 parsecs from each other.

Another tool we used to help determine the nature of these double stars is the "rating" calculation of Harshaw (2014). Using proper motion data from Gaia Data Release 3, the statistic was calculated for each system and is reported in Table 7 (for WDS 20310-2700) and Table 8 (for WDS 20313-2707). The resulting value for WDS 20313-2707 (0.5%) indicates a common motion pair and therefore likely to be a binary system. A "rating" of 18.4% for WDS 20310-2700 is at the end of the range for star systems with known orbits (Harshaw, 2014). However, it is closer to the ratings of binary systems than to those with linear solutions.

Table 7: Proper motion from Gaia Data Release 3 with calculated proper motion "rating" (Harshaw, 2014) for WDS 20310-2700.

Star	Proper Motion RA (mas/yr)	Proper Motion Dec (mas/yr)	Mag. of PM Diff. (mas)	Sum of PM Mags. (mas)	Rating (%)
Primary	18.708 ± 0.015	-21.331 ± 0.012	9.07	49.22	18.4
Secondary	16.699 ± 0.016	-12.486 ± 0.013			

Table 8: Proper motion from Gaia Data Release 3 with calculated proper motion "rating" (Harshaw, 2014) for WDS 20313-2707.

Star	Proper Motion RA (mas/yr)	Proper Motion Dec (mas/yr)	Mag. of PM Diff. (mas)	Sum of PM Mags. (mas)	Rating (%)
Primary	-74.67 ± 0.17	-47.341 ± 0.14	0.913	177.6	0.5
Secondary	-75.469 ± 0.019	-48.100 ± 0.014			

5. Conclusions

We used our observations to measure separation and position angles for two double star systems. In both cases, our observations are similar to those in the historical record.

Parallax and proper motion data for WDS 20313-2707 indicated a very high likelihood that this system is binary. However, the 46 years of data are not enough to calculate an orbit. More observations in the future are needed to obtain orbital information.

For WDS 20310-2700, only 25 years of data exist. Without more data, an orbit cannot be calculated. The parallax and proper motion data are more ambiguous for this system. The stars are relatively close to each other on the cosmic scale, but are very far compared to most binary systems. The proper motion "rating" is nearer to known binary systems than to those that are only optical double star systems (Harshaw, 2014).

But it is also high compared to most known binary systems. The nature of this system must remain unknown until more data is available.

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