Investigation of Historical Data & Astronomical Measurements of WDS 05134+3727

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Abstract

The star system WDS05134+3727 is a triple-star system that was first observed in 1895 and has since been measured 12 times. Our aim was to add additional measurements of separation and arc length for the components of this system. AstroImageJ was used to measure the arc lengths and position angles of all three components, and the results were compared to the historical observations. All components appeared to show linear motion with relation to the other components, suggesting that they are not physical. To further our study, Gaia DR2 data were obtained for the components of the system. The parallax and proper motion of the A and B components are quite similar, suggesting that they are physical; however the relatively large reduced unit weight error (RUWE) for the B component casts some doubt on this. The Gaia data for the C component also has a large RUWE, but its parallax (0.9 mas) is so different from that of the A component (4.97 mas) that we feel confident in stating that the A and C components are not physical.

Introduction

For this paper, we observed WDS05134+3727, a triple star system. This system was selected because it was visible at the time of this project, and the magnitudes and separations of the components are within the range of what can be observed with the Great Basin Observatory (GBO). The AB component of our system has been observed 10 times, while the AC component has 7 measurements, and the BC component has 8 past observations. The most recent observation of the system was in 2015, while the earliest observations for AB was 1895 and for AC was 1999. These historical data suggest that the components are moving in a linear fashion, however we sought to confirm this by providing additional measurements for the system. Additionally, we sought to confirm the motions of the stars by extracting parallax and proper motion data from the Gaia database.

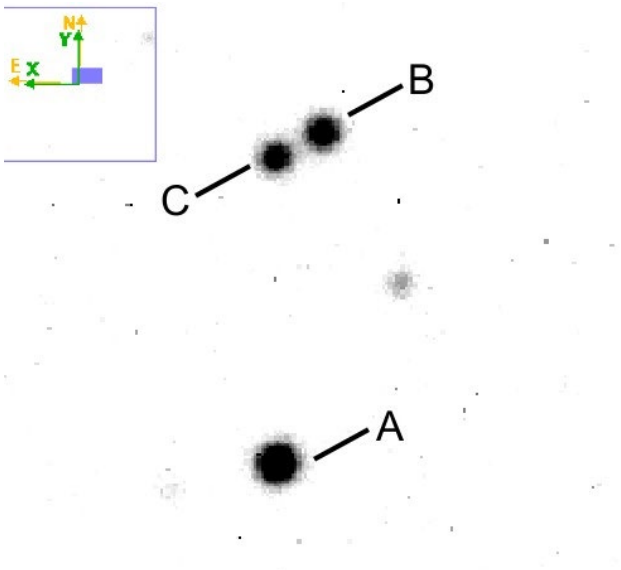

Figure 1: Image of the A, B, and C components

Methods

We observed this system using the Great Basin Observatory located in Great Basin National Park. This observatory is equipped with a PlaneWave 0.7m CDK 700 telescope with a SBIG STX-16803 CCD camera, which produces a plate scale of 0.4 arcsec per pixel. The GBO telescope has a focal ratio of f/6.5, which produces a field of view of 27 x 27 arcminutes. The telescope is equipped with 16 filters: LRGB, BVRI, g'r'i'z', Ha, OIII, SII, and a diffraction grating (Anselmo et al. 2018). This observatory is managed and maintained by a consortium consisting of Great Basin National Park and the Park's foundation, Southern Utah University, Concordia University, University of Nevada-Reno, and Western Nevada College.

Fifteen images of this star system were taken on November 10th, 2021. Figure 1 shows the stars of the system with the components labeled. These images had an exposure time of 60 seconds, the binning was set to 1x1, and the V filter was used. We used AstroImageJ (Collins et al. 2017) to verify that the components of the system were not overexposed. AstroImageJ was also used to reduce the images. The astrometry of the system was provided by http://nova.astrometry.net/ (Lang 2010). AstroimageJ was then used to measure the separation (ρ) and position angle (θ) of the stars. The average, standard deviation, and standard error of the measurements from the 15 images was determined.

Results

Table 1 shows the outcome of our measurements. It includes the separation and the position angle for each set of components, as well as the mean, the standard deviation and the standard errors.

WDS	Date Taken	Number of Images		Separation Rho (ρ)	Position Angle Theta (θ)
05134+3727AB	11-10-2021	15	Mean	43.42	354.94
			Std. Dev.	0.045	0.039
			Std. Error	0.012	0.01
05134+3727AC	11-10-2021	15	Mean	39.88	2.90
			Std. Dev.	0.022	0.023
			Std. Error	0.006	0.006
05134+3727BC	11-10-2021	15	Mean	6.82	120.78
			Std. Dev.	0.048	0.446
			Std. Error	0.012	0.115

Table 1: 2021 Statistical Values of Separation (ρ) and Position Angle (θ) *of WDS 0134+3727AB, AC, & BC Components.*

Discussion

We requested historical data from the US Naval Observatory (Matson, 2021) for comparison with our measurements of WDS05134+3727. These historical measurements, as well as our new measurements for all components, are shown in Table 2. We have plotted the measurements of the AB component in Figure 2. However two of the data points, one from 1982 and another from 2007, appear to be discrepant and are not shown. Perhaps a typo or detector problem resulted in the observed error in the reported measurement. In this plot we see a fairly linear relationship in the motion of the B component relative to the A component. Over the past 126 years the position angle has decreased by 3.36 degrees and the separation has increased by 14.08 arcsec. Taken together, the linear motion of the B component suggests that it is not physically associated with the A component.

In an effort to further understand the nature of the AB component, we requested Gaia data for this system (Gaia Collaboration, 2016, 2018). This data is shown in Table 3. We can see that the parallax for component A is quite different from that of component B, as is the proper motion for these components. Furthermore, the reduced unit weight error (RUWE) of both components is quite good. Lindegren (2018) suggests that for Gaia data to be considered "well behaved" the RUWE should be less than 1.4. The RUWE for both components is less than this natural break point, suggesting a high confidence in these measurements. Taken together with the apparent linear motion of the system, it seems that the AB component of WDS05134+3727 is not physical.

We see a similar result for the AC components. Table 2 shows that AC has 8 measurements including our own, while Figure 3 shows a plot of these data. Although the motion of the stars appears to be roughly linear, there appear to be a few discrepant points here as well. This linear motion suggests that the stars are not physically associated. The Gaia measurements for this pair confirms this. The parallaxes for these components are quite different, with a distance of 2,000 parsecs between them. Furthermore, the proper motions are also dissimilar, providing further evidence that the stars are not physically associated. The RUWE for the C component is also quite good, suggesting that the parallax and the proper motion for this component are reliable. This confirms the A and C components are not physically associated.

For the BC component of this system, 10 measurements, including our own, have been taken and can be found in Table 2. These values are plotted in Figure 4. Although there appears to be a linear fit, the motion of this system over the last ~120 years is less than 1 arcsec. The Gaia data for the pair indicates that they are not physical, as they are separated by about 300 pc. The proper motion values for this pair are dissimilar, as would be expected for stars that are not physical.
In summary, based on Gaia data and our plots of historical measurements, we can conclude that none of the components in this system are physically associated.

AB			**AC**			**BC**		
Year	Theta (θ)	Rho (ρ)	Year	Theta (θ)	Rho (ρ)	Year	Theta (θ)	Rho (ρ)
1895	358.3	29.34	1999	2.90	39.97	1895	123.2	6.14
1895	358.0	29.31	2002	2.80	40.0	1895	122.8	6.15
1983	358.8	41.97	2007	2.34	40.06	1999	121.9	6.78
1999	355.1	43.66	2013	2.99	49.90	2002	121.5	6.80
2002	355.1	43.62	2014	2.99	39.89	2007	120.9	6.70
2007	4.49	38.02	2015	3.00	39.88	2013	120.9	6.83

2007	354.62	43.49	2015	3.01	39.88	2014	120.9	6.83
2013	355.03	43.53	2021	2.90	39.88	2015	120.9	6.84
2014	355.02	43.51				2015	120.9	6.84
2015	355.01	43.51				2021	120.3	6.78
2015	355.02	43.50						
2021	354.94	43.42						

Table 2: Historical measurements for the system.

Component	Parallax (mas)	Distance (pc)	RA Proper Motion (mas/year)	Dec Proper Motion (mas/year)	RUWE
A	0.38±0.013	2550 - 2700	0.363±0.015	-1.304±0.011	1.100
B	1.88±0.015	528 - 536	-3.601±0.017	-13.445±0.013	0.971
C	1.24±0.014	800 - 816	3.447±0.016	-9.446±012	0.923

Table 3: Parallax and Proper Motion Data taken from the ESAś Gaia Database. (Luri et al. 2018)

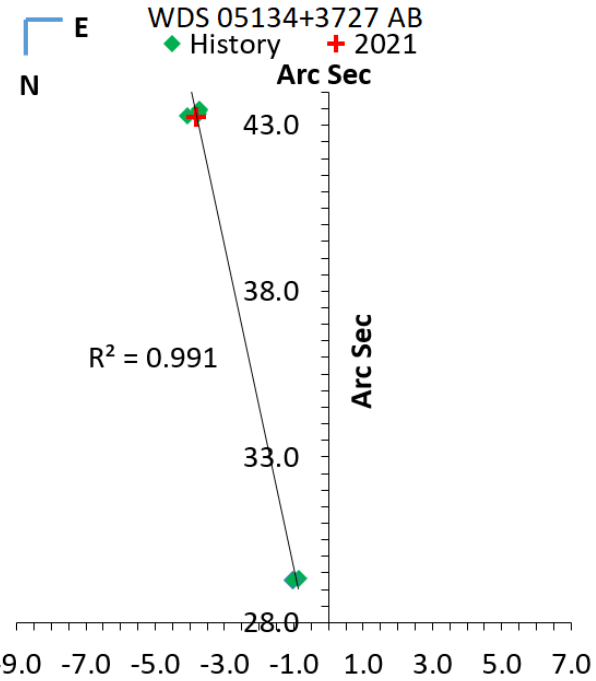

Figure 2: Historical Data for Separation between AB Components. Two of the data points were apparent outliers and have been omitted. This pair seems to exhibit linear motion.

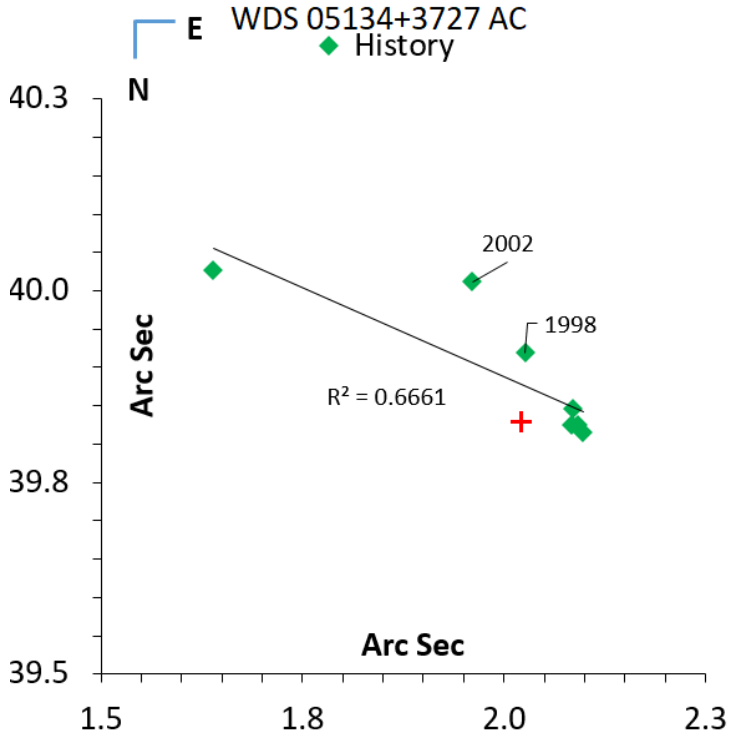

Figure 3: Historical Data for Separation between AC Components. Although this plot appears to show linear motion, there are a few discrepant measurements from 2002 and 1998.

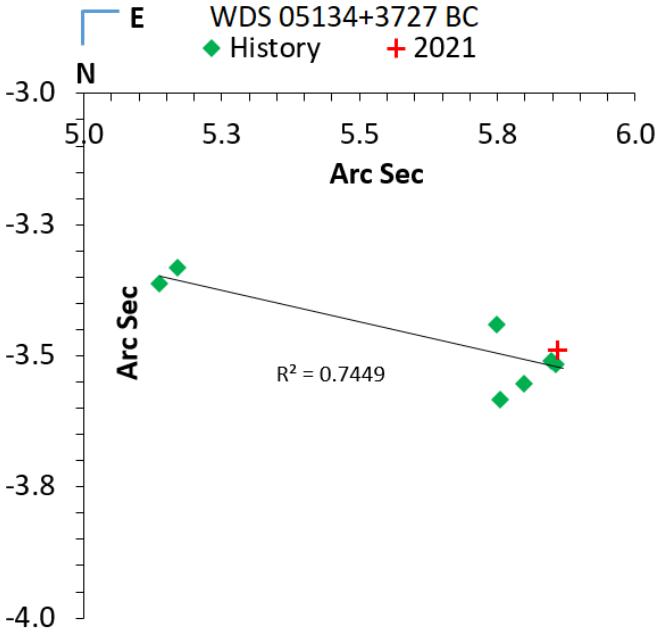

Figure 4: Plot of historical data for the BC Components. This appears to show linear motion, however there has not been much change in position over the last 120 years.

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