An Astrometric Observation of Binary Star System WDS 00057+4549

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Abstract: A student research team from Cuesta College imaged and analyzed the double star system WDS 0057+4549 using a PlaneWave 0.7-m CDK 700 telescope located at the Sierra Nevada Observatory. Using these images, the team measured the position angle and separation of this double star system. Using AstroImageJ, the team calculated the mean separation to be 6.01" with a mean position angle of 189.27°. This new observation agrees with the existing values for system WDS 00057+4549.

Introduction

Two stars that appear close together, within about one arcminute, are considered to be double stars. Double stars fall into one of two categories: optical doubles, which only appear close due to perspective, and binary doubles, which are gravitationally bound to one another. If a pair of stars happen to be binary, they can be quite valuable to astronomers; if the elliptical orbit of the stars is deduced, via data gathered from the pro-am community, astronomers can use Kepler's laws in collaboration with the stars' distance from the earth to determine the combined mass of the two stars (dynamic mass). This information can then be used to determine a plethora of different facts about the stars and their systems, such as age and composition.

This observational study of WDS 00057+4549 was designed to be run by student astronomers, with professional collaboration, where they conduct their own research and data analysis (Genet et. al. 2017). The purpose of this study was to engage student astronomers with the scientific process while introducing the research team to the use of remotely accessed robotic telescopes and astrometric data analysis.

The double star system WDS 00057+4549 was selected out of thousands of systems due to its existing history of observation and its adherence to a specific set of criteria. These criteria included being within 10″ of each other but no less than 5″, being observable with the CDK 700 telescope at Sierra Remote Observatories, and having discernible contrast between the primary and secondary star. These criteria were designed to accommodate the equipment available to the research team. Our measurements were then added to existing measurements to confirm (or suggest modifying) the current projected orbit of WDS 00057+4549.

Equipment and Analysis

The images analyzed in this study were collected with a CDK 700 telescope designed by contributor Dave Rowe and build by PlaneWave Instruments (CDK 700 2017). The telescope was located at the Sierra Remote Observatories (Figure 1), an observatory of robotic small telescopes that participate in the pro-am community.

Located in the Sierra Nevada mountains. The observatory obtained 10 high quality images of WDS 00057+4549 with an Apogee alpha 4000 pixel camera with a 350mm field of view. The images were analyzed with AstroImageJ image processing software (Collins et al. 2017). The images were analyzed with regards to separation in arcseconds and the position angle of the secondary with respect to the primary and celestial north.

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Figure 1. Sierra Remote Observatory, California USA. N 37.07 W 119.4. Overlooking the staging area of the remote telescopes.

Under Multi-Aperture Measurements, the radius of object aperture was set to 4 (pixels). In six of ten images plate solutions were obtained, but plate solving failed in four cases. For those with a plate solution, the images were magnified and adjusted until there were clearly two different stars. We moved the cursor over the left star, centered the blue four-pixel radius circle over the star, then pressed down the scroll wheel, dragged the mouse until the blue circle was roughly centered over the right star, and let up on the scroll wheel. The solution showed up on the image and was recorded. Some images were rejected due to saturation as indicated by the image processing software AstroImageJ.

Data

Table 1 shows data on WDS 00057+4549 analyzed via AstroImageJ. The average position angle of the bodies observed in this study was 189.27° with a σ of ± 0.13°, and the average separation was 6.01" with a SD of ± 0.04" (See Table 2.)

Discussion

WDS 00059+4749 has been observed since the late 1800s by both professional and amateur astronomers, with data cataloged by the US Naval Observatory (USNO 2017). The Position Angle vs. Time graph below (figure 2), after the removal of incomplete data and extreme outliers, displays data collected between 1873 and 2016. The existing data from this system suggested an elliptical path, characteristic of binary stars. After plotting the data we collected from the images obtained on Nov. 12 2017 the team was able to add additional data points. These data points were concurrent with the path established by previous observations.

Table 2: The mean, σ, and standard error of the mean for both the separation(ρ) and position angle(θ), using data from the images in table 1.

	Separation (ρ) °	Position Angle (θ) ″
mean	6.010	189.35
standard deviation	0.134	0.019
standard error of the mean	0.053	0.008

Table 1: The 10 celestial images collected by the Sierra Nevada Observatory on 11/12/2017. This includes the separation(ρ) of the two celestial bodies and their position angle (θ). Images 2,6,7, and 9 were unable to be processed yielding no data.

Image	Separation(ρ) °	Position Angle(θ) ″
1	5.99	189.34
2	N/A	N/A
3	6.01	189.41
4	5.99	189.15
5	5.98	189.37
6	N/A	N/A
7	N/A	N/A
8	6.01	189.25
9	N/A	N/A
10	6.00	189.08

Conclusion

The new observation obtained during this study was consistent with previously obtained data. While a portion of the images had to be excluded, the remaining images, in conjunction with the previous research, provided sufficient evidence to support the proposed existing elliptical path.

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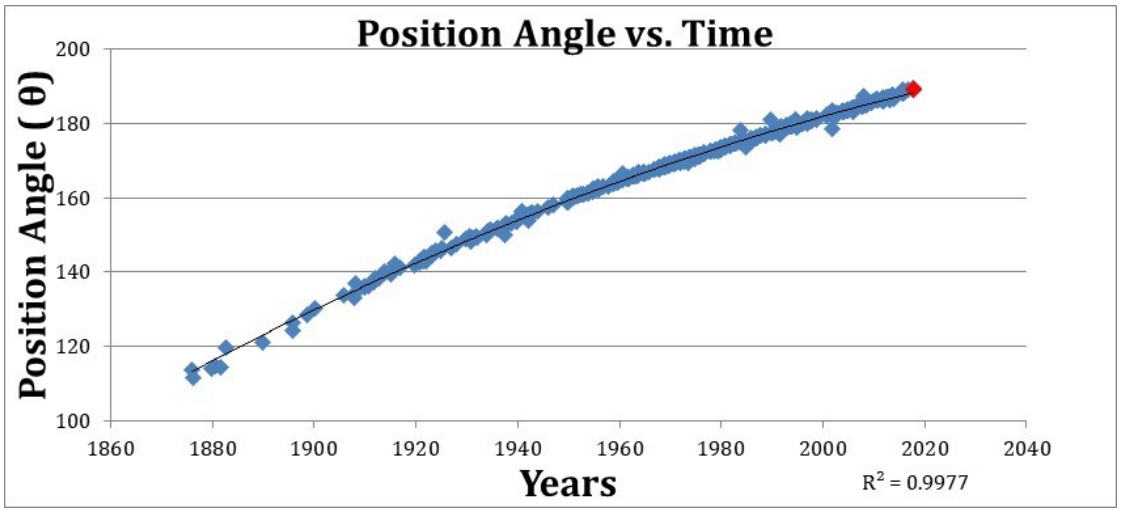

Figure 2. The position angle(θ) from previous observation in relation to the years they were made. The blue dots represent the data collected during previous studies, the red dot represents the data added from this study.

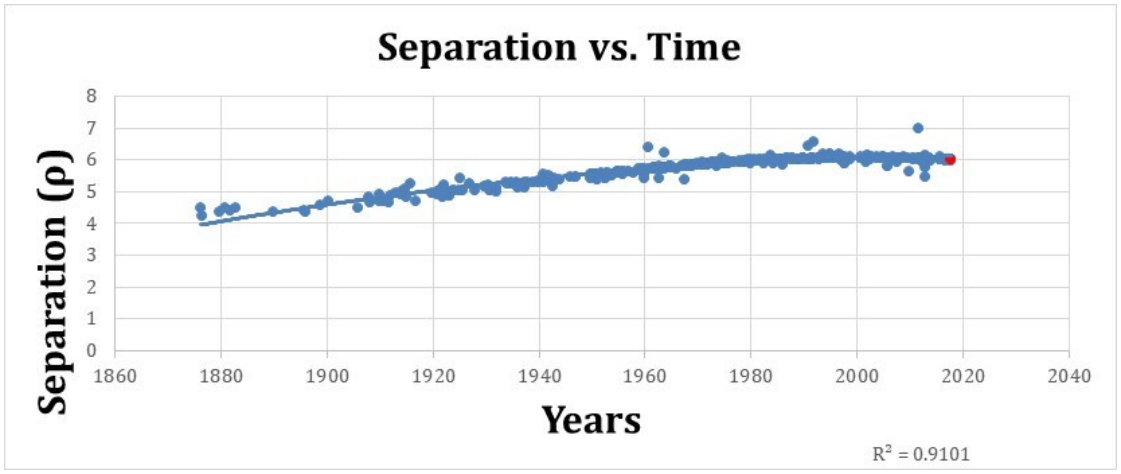

Figure 3: The Separation (ρ) of the celestial bodies from previous observation in relation to the years they were made. The blue dots represent the data collected during previous studies, the red dot represents the data added from this study.

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