CCD and Gaia Measurements Indicate that WSD 12095 + 3356 is a Physical System

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Abstract: The Double Star System WSD 12095 + 3356 was observed using the Great Basin Observatory telescope. The images were plate solved and calibrated, and then position angle and separation were measured using AstroImageJ. Our measurements (θ = 324.131° and ρ = 63.490") were compared to historical observations. Parallax and proper motion data from the Gaia database indicate that the stars in this system are physically associated.

Introduction

The goal of this project was to provide additional measurements of the separation and position angle to determine if WSD 12095 + 3356 is a binary system. WSD 12095 + 3356 is recorded as a double star with components A and B. It was first observed in 1998 and most recently in 2015, with a total of six observations. This system was selected because it could be viewed with the Great Basin Observatory (GBO) Telescope. This research was done by high school students from SUCCESS Academy (an early college high school) in collaboration with Southern Utah University.

Methods

This research was conducted using the telescope at the Great Basin Observatory in Great Basin National Park (Figure 1). The GBO is the first research grade telescope in a national park. It is managed by the Great Basin National Park and the Great Basin National Park Foundation, in collaboration with Concordia University, Southern Utah University, University of Nevada-Reno, and Western Nevada College. The telescope has an aperture of 27 inches (Anselmo et al. 2018).

The images of WSD 12095 + 3356 (Figure 2) were acquired remotely on February 22, 2018. A total of 26 images were taken with an exposure time of 180 seconds with the V filter. The exposure time was chosen so the target stars would not be over-exposed. The images were binned 1x1. Images were plate solved using astrometry.net and then the images were calibrated by applying dark, bias, and flats using AstroImageJ version 3.2.27 (Collins et. al 2017). Position angle (θ) and separation (ρ) were measured through AstroImageJ.

Figure 1. The Great Basin Observatory and the control room (Anselmo et al. 2018).

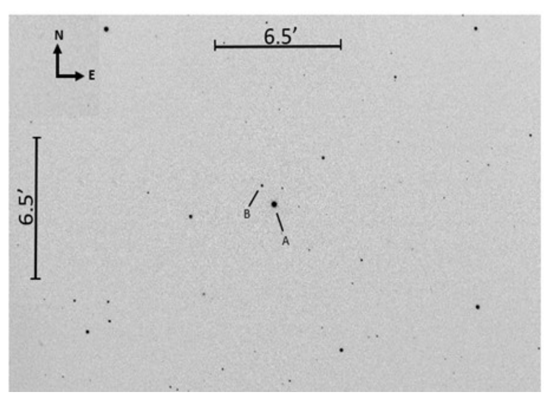

Figure 2. Image of A and B components of WSD 12095 + 3356. Plate scaled at 0.4 arcsec/pixel.

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WDS No.	ID	Nights	Date	Observations		θ°	ρ″
12095 + 3356	GRV 853	1	JD2458172 Feb.22,2018	26	Mean	324.131	63.490
					Std. Dev.	0.028	0.230
					Std. Error	0.056	0.005

Table 1. Observations from the data collected. θ, ρ, mean, standard deviation, and standard error.

The centroid feature was used to improve accuracy by measuring from the center of each star. All data was exported into Excel to calculate the mean, standard deviation, and standard error for θ and ρ.

Results

The mean, standard deviation, and standard error were measured for the star system, and the results are shown in Table 1.

Discussion

Table 2 shows the historical data for WSD 12095 + 3356. The measurements cover 1998 to 2015 with six observations in total. In Figure 3, the measurements are shown, with the primary star at (0,0). All of the data is in the same range, but there are two possible outliers. As seen in Figure 4, either the original observation in 1998 or the 2004 data could be an outlier. Stars do not move several arcseconds away then return to their previous positions. This could mean that the data from 2004 is be spurious, as Figure 4 shows that with the exception of the 2004 data point, the other observations suggest a more linear form for the motion of the B component.

To further determine if the stars are physically associated, we retrieved data from the Gaia database (Gaia Collaboration, 2018) for the parallax and proper

Epoch	θ°	ρ″
1998.19	324.0	63.770
2000	324.0	63.600
2002.04	324.0	63.568
2004.205	324.500	63.395
2010.5	324.100	63.560
2015	324.064	63.581
2018.17	324.131	63.490

Table 2. Historical Data for WSD 12095 + 3356.

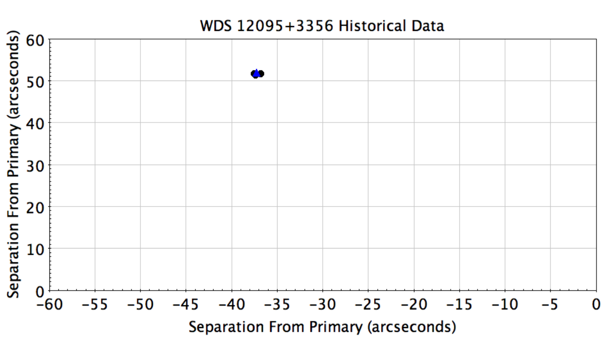

Figure 3. This graph shows our measurements (orange triangle) along with historical measurements (blue circles) around the primary star. The measurements are in arcseconds. In this graph, the primary star is located at the origin.

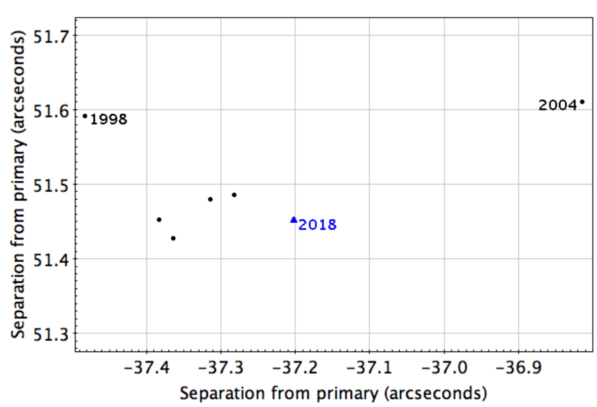

Figure 4. A closer look at the historical data (blue circles) and collected data (orange triangle). The data points suggest the secondary star is orbiting the primary star, but there is one discrepant data point, which is the 2004 measurement.

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Component	Right Ascension	Declination	Parallax [mas]	Parallax Error [mas]	Proper Motion RA	Proper Motion DE
A	182.391	33.944	5.847	0.077	-59.935	12.358
B	182.379	33.958	5.840	0.045	-59.319	12.661

Table 3. Data obtained from the ESA Gaia telescope (Gaia Collaboration, 2018). Both the parallax and proper motion data indicate that the stars are indeed a binary.

motion of each star. The coordinates of the stars are given in the second and third column of Table 3. The parallax is the measurement of how far away the stars are from Earth. When the parallax is converted to parsecs we find that both stars are at a similar distance (171 parsecs). However, since Gaia's accuracy begins to drop off around 5 mas, we can only conclude that the stars in this system are physically associated. Table 3 shows that both stars have similar proper motion in declination and right ascension, which further suggests they are physical stars. The distance data agrees with the proper motion data; both stars are at a similar distance and moving the same way, which indicates that the system is physical. To determine if this pair forms a binary system, an orbit would need to be computed.

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