Double Star Measurements of WDS 13367+2847 (GRV870AB)

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Abstract: Using data from Global Astrometric Interferometer for Astrophysics (GAIA), Washington Double Star Catalog and Aladin 10, we gathered data about WDS 13367+2847 GRV870AB, C, further referred to as GRV870AB, C. This data includes magnitude, distance and proper motion. Our objective was to analyze whether star AB may be gravitationally bound to C. Images of GRV870AB, C were acquired using the remote telescope network Las Cumbres Observatory (LCO) using a 0.4-meter modified Meade telescope. From the images we calculated the mean position angle and separation of AC 118.70° ± 0.03° and 22.49" ± 0.019" on 2019.289.

Introduction

This research, part of an Astronomy Research Seminar conducted by Boyce Research Initiatives and Education Foundation (BRIEF) and offered by San Diego Mesa College, explored the history of WDS13367+2847 GRV870AB, C, Figure 1, and took measurements to provide an updated Theta (position angle) and Rho (angular separation) measurement for this pair. Data was collected using GAIA, the Washington Double Stars Catalog (WDS), and Las Cumbres Observatory (LCO) remote telescopes. GAIA is a telescope launched by the European Space agency in 2013 with a mission to catalogue a billion stars and chart their position, distances, motion and changes in brightness over a five-year period. It is expected to be 10,000 times more accurate than Hipparcos (GAIA, 2016).

The first measurement of GRV870AB, C was taken in 1896 measuring theta of 117.3° and rho 22.57" (Mason, 2019). Measurements of theta at 118.7° and rho 22.53" were recorded in 2001. Proper Motion of GRV870AB, C is recorded as -24.43 for star AB and -21.64 for star C. One component of our star system, the AB pair, are two stars closely spaced together making it difficult to distinguish them apart from each other without the use of spectroscopy hence the designation of AB. Based on the proper motion of the stars (GAIA, 2016) we decided to see if star C may be gravitationally bound to AB.

Materials and Methods

Images of GRV870AB, C were requested via the Las Cumbres Observatory (LCO). A 0.4-meter modified Meade telescope with a SBIG STX-6303 CCD camera, located at Mt. Haleakala, Hawaii, 10,000 feet above sea level, was used to acquire images of this pair. It provided a resolution of 1.14"/pixel and a field of view of 19′ x 29′ arcminutes.

A total of 10 images were acquired with the following filter and exposure configurations: clear filter at an 8, 10, and 12 second exposure times, and an SDSS g filter at 5 and 7 second exposure times. Because both the AB and C stars are G0 class stars, the clear filter was used. The peak wavelength emitted by G0 class stars is in the yellow range of visible light, so the bandpass of the g filter captures the most light for this system. The exposure times were calculated through the LCO Exposure Time Calculator, taking into account the magnitude of the stars, filter and telescope used, moon phase, air mass, and PkDN (peak number of counts) in the image.

The images were processed through the Our Solar

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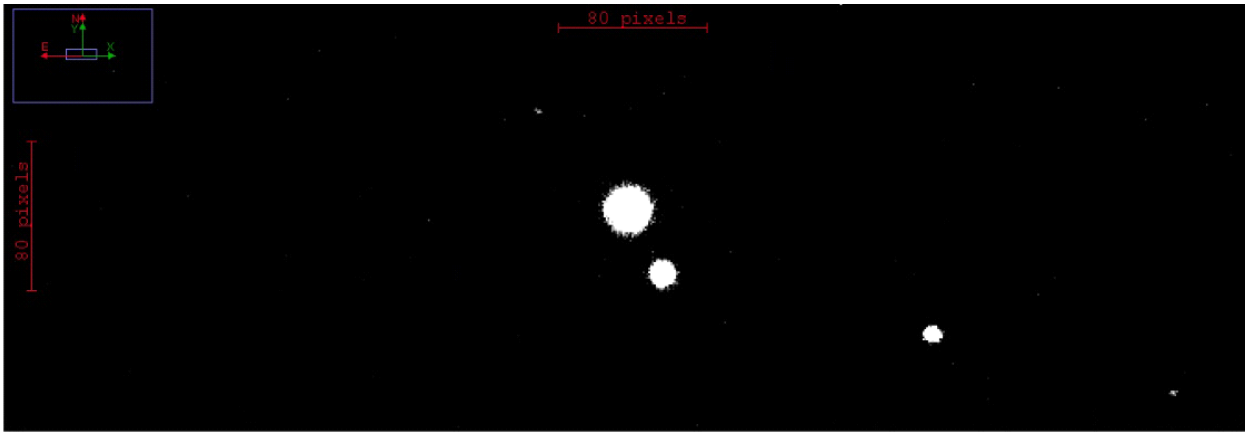

Figure 1. Image of GRV870AB,C

Siblings (OSS) Pipeline (Fitzgerald, 2018). The OSS Pipeline removed bad pixels, cosmic rays, any known camera defects and inserted the World Coordinate System (WCS). The separation distance and angle between the stars were determined using the application AstroImageJ (Collins, et al. 2017).

Results

To eliminate human error, two sets of independent measurements were taken for the data set: Trial 1 and Trial 2. Using AstroImageJ the calculated position angle is 118.70° and separation is 22.50". These results and statistics are summarized in Tables 1 and 2.

A graph of the historical data in addition to our measurements of theta and rho, Table 3, provides an illustration of the historical measurements, Figure 2.

Table 1. Calculated Separation and Position Angle of 10 Images

Image Number	Trial 1 Position Angle (deg)	Trial 1 Separation (as)	Trial 2 Position Angle (deg)	Trial 2 Separation (as)
1	118.70°	22.52"	118.78°	22.53"
2	118.85°	22.51"	118.87°	22.51"
3	118.63°	22.48"	118.60°	22.47"
4	118.68°	22.51"	118.77°	22.50"
5	118.65°	22.51"	118.72°	22.52"
6	118.61°	22.55"	118.56°	22.50"
7	118.76°	22.50"	118.74°	22.48"
8	118.70°	22.48"	118.70°	22.49"
9	118.67°	22.55"	118.68°	22.53"
10	118.73°	22.46"	118.57°	22.40"
Trial Average	118.70°	22.51"	118.70°	22.50"
Standard Deviation	0.07°	0.03"	0.09°	0.04"
Standard Error of Mean	0.02°	0.01"	0.03°	0.01"

Table 2: Measurement Mean and Statistical Error for AB, C.

	Theta	Rho
Mean	118.70°	22.50″
Standard Deviation	0.08°	0.05″
Standard Error of Mean	0.03°	0.01″

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Table 3: Table of Historical Data plus 2019.289 Measurements

Year	Theta	Rho	Observation
1896.31	117.3°	22.57″	WFC1998
1902.48	119.3°	22.58″	WFC1998
1999.32	118.7°	22.44″	TMA2003
2000	119.0°	22.50″	GRV2004
2001.468	118.7°	22.53″	UC_2013
2019.289	118.7°	22.50″	Our Data

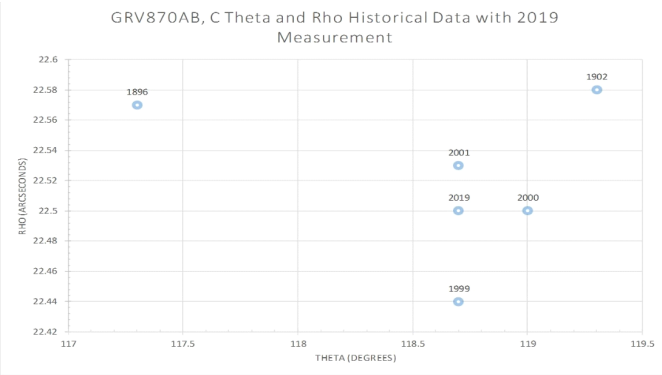

Figure 2: Historical Data plus 2019.289 Measurements of Theta and Rho. The X axis represents theta and the Y axis represents Rho. The year the observation was taken is shown above each dot.

Discussion

Stelle Doppie listed this system as a physical double and a triple system (Stelle Doppie Web). The possibility of the system being a triple star system is why we chose GRV870AB, C. There have been 5 observations of GRV870AB, C since 1896. In addition to our CCD measurements in this paper, we also addressed the radial velocity, proper motion and parallax from the GAIA data.

The radial velocity for AB is listed at -24.43 mas/yr and C was -21.64 mas/yr (Gaia, 2018). Proper motion data for star AB had an RA of 18.93 mas/yr and Dec of 8.5 mas/yr and proper motion for star C had an RA of 12.27 mas/yr and Dec of 11.82 mas/yr (Gaia, 2018).

Parallax, the distance to the star, for AB is 8.36 with a parallax error of ± 0.35. Parallax of star C is 4.69 with a parallax error of ± 0.033 (GAIA, 2018). Converting these distances to parsecs, the AB distance is 120 pc, uncertainty (± 5 pc). C distance is 213 pc, uncertainty (+2, -1 pc), Figure 3.

Comparing the historical measurements with data from this paper, the theta and rho measurements are consistent. When consulting GAIA data to complete the analysis of this system, the radial velocity and proper

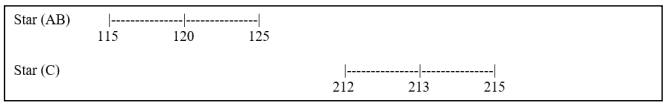

Figure 3. Graphical representation of parsecs with error bars.

motion show similar values yet show differences given a rough margin of error. The radial velocity of the AB star show that it is moving away from us at a faster rate than the C star. When looking at the proper motion of both stars, Gaia shows that the stars are moving around the celestial sphere at different rates, in which the AB star is changing its position faster The difference in proper motion and radial velocity indicate that the AB star and the C star are not moving together as a system. This is indicative of an optical double. Parallax was the major factor in determining if the stars were gravitationally bound. Due to the large difference in parallax and probability that there is no overlap even with errors, the C star appears to not be gravitationally bound to the AB stars.

Conclusion

Although the stars have similar radial velocity and increasing proper motion it appears that the C star is not gravitationally bound to the AB star due to no overlap in the parallax. With this information we are suggesting this system may be a Y in accordance with the WDS Summary Catalog note flags (Washington Double Star Catalog, 2018). The Y note states: Statistically different parallax for the components indicates they are non-physical.

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