Astrometric Measurements of OSO 51 AB

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Abstract: The double star system WDS 13111+1220 OSO 51 AB was studied by a team of students using the Las Cumbres Observatory (LCO) to analyze the nature of the double star. Images were measured for position angle (Theta) and separation distance (Rho) through image analysis software AstroImageJ. The position angle was measured to be 299.33° and the angular separation was measured to be 11.467" arcseconds. It was determined through measurements and Gaia parallax data that the double is most likely an optical double and not a physical binary.

Introduction

The objective of this research was to observe and measure double star system WDS 13111+1220 OSO 51 AB. OSO 51 AB was discovered by Maria Rosa Zapatero Osorio in 1994 (Stelle Doppie Web) and has been observed 7 times from 1994 to 2001.

A primary factor considered in the selection of OSO 51 included choosing a double star system with the necessary Right Ascension (RA) for observation, between 08-14 hours, as observations were taken in spring. The difference in magnitude was also taken into consideration with the magnitudes for the A and B stars of 14.22 and 15.50 respectively, resulting in a delta magnitude of 1.28, low enough for neither star to obscure the other from view in a CCD image. The third star, C, of OSO 51 AC, with a magnitude of 19.1, was too dim to be seen in an image even with a high exposure time and could not be studied with the resources available.

The nature of OSO 51 as an optical double star system or as a binary system was to be reviewed by these observations. Proper motion and parallax are often used to determine the nature of double stars. The team used Aladin10 to find proper motion vectors for the two stars, Figure 1. Parallax is the angle subtended by the star on opposite sides of the Earth's orbit. This can be used to find the distance of the star from Earth. Stars which are very different distances from Earth, and therefore far from each other, are usually not gravitationally bound.

After requesting historical WDS data for the system, it was noted there are 7 historical measurements with the first in 1994 and the latest, before this paper, in 2001. These measurements are plotted in Figure 2. Then, a linear trendline was compared to a polynomial trendline, Figure 3 and Figure 4, for the data, and there seemed to be some sort of non-linear trend that might indicate an orbit.

Methods and Materials

The Las Cumbres Observatory (LCO) telescope network was used to acquire images. Images were captured by a 0.4-m Meade 6303 telescope, Figure 5, with an SBIG CCD camera resulting in a pixel size of 0.571" binned 1x1. The images had a field of view of 29'x19' and were taken at Haleakala Observatory, Hawaii, at 10,000 feet above sea level. Due to the dim nature of both stars in the system, no filter was used while ob-

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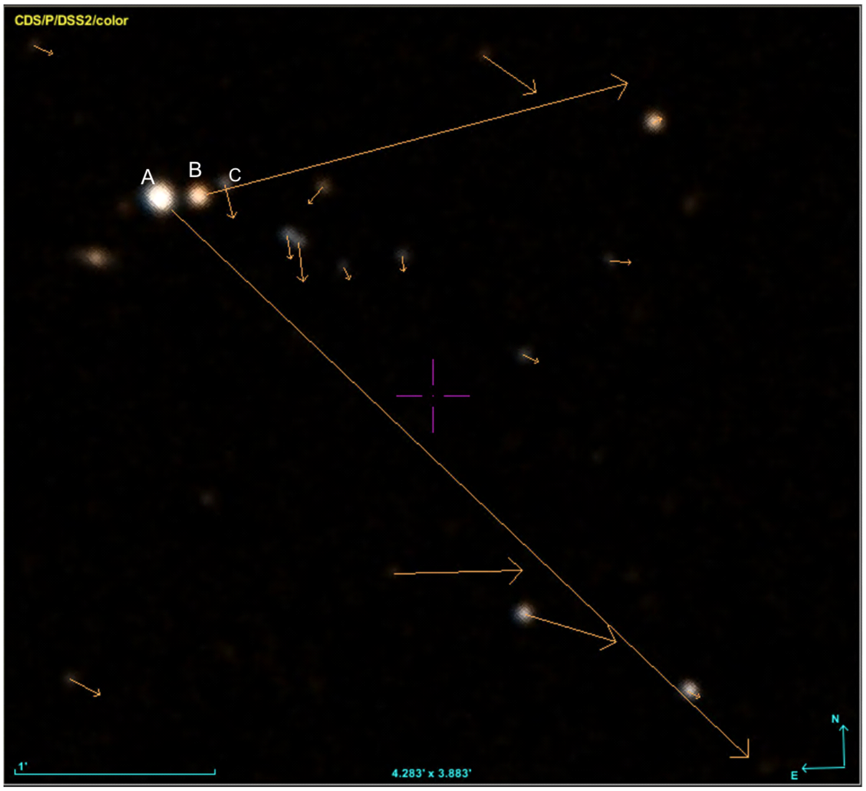

Figure 1. WDS 13111+1220 as shown on Aladin 10 with proper motion vectors.

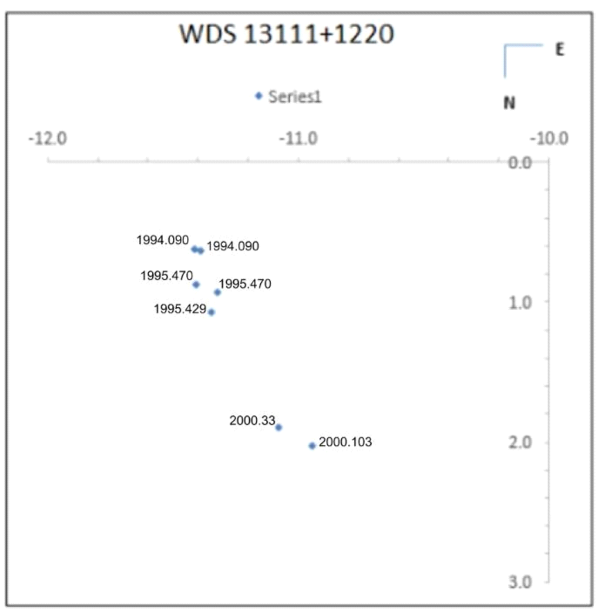

Figure 2. Graph of historical data.

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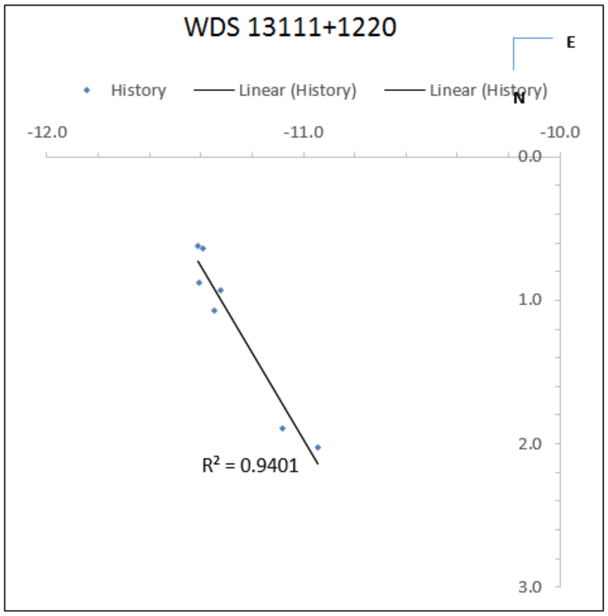

Figure 3. Graph of historical data with linear trendline

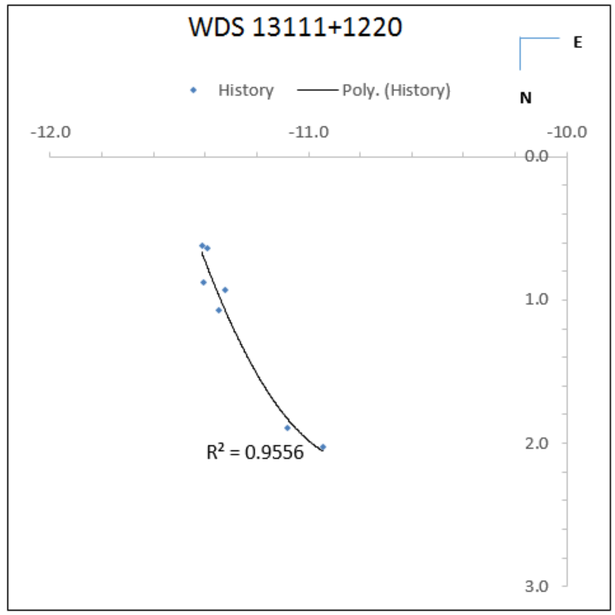

Figure 4. Graph of historical data with polynomial trendline

#	Theta (°)	Rho (")
1	299.51	11.393
2	296.84	11.923
3	301.96	11.337
4	299.05	11.551
5	299.29	11.510
6	300.14	11.000
7	298.25	11.523
8	298.86	11.530
9	299.02	11.529
10	299.22	11.572
11	299.83	11.344
12	299.11	11.373
13	299.18	11.430
14	299.96	11.515
15	299.78	11.473
Avg	299.33	11.467

Table 1. Measurements from new observations with final average. All measurements were made on Besselian date 2019.284, JD 2458588.

taining images with an exposure time of 300 seconds. 15 images were taken on 2458588.291667 (BJD).

Images were processed through the Our Solar Siblings (OSS) pipeline (Fitzgerald 2018) to ensure image quality and ease for measurement, by embedding World Coordinate System (WCS) coordinates, calibration, and photometry. AstroImageJ was used to measure separation distance and position angle.

Data and Results

Two team members independently took measurements which were then averaged to ensure greatest accuracy. Measurements of Theta and Rho are provided, Table 1. The mean position angle was calculated to be 299.33°, and the mean separation was 11.467", Table 2. The standard deviation of position angle was 1.079 and the standard deviation of separation was 0.191, indicating the data was fairly consistent, Table 2. A combination of the historical measurements with Theta and Rho from this paper are provided, Table 3. The average of all measurements is plotted in Figure 6. The data was graphed, showing how it made sense and seemed rea-

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Epoch	# of obs.	Mean PA	Std. Dev.	Mean Sep.	Std. Dev.
2019.284 JD2458588	15	299.3	1.1	11.47	0.19

Table 2. Mean Position Angle (Theta) and Angular Separation (Rho) with related statistics.

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Figure 5. 0.4-m Meade telescope provided by LCO.

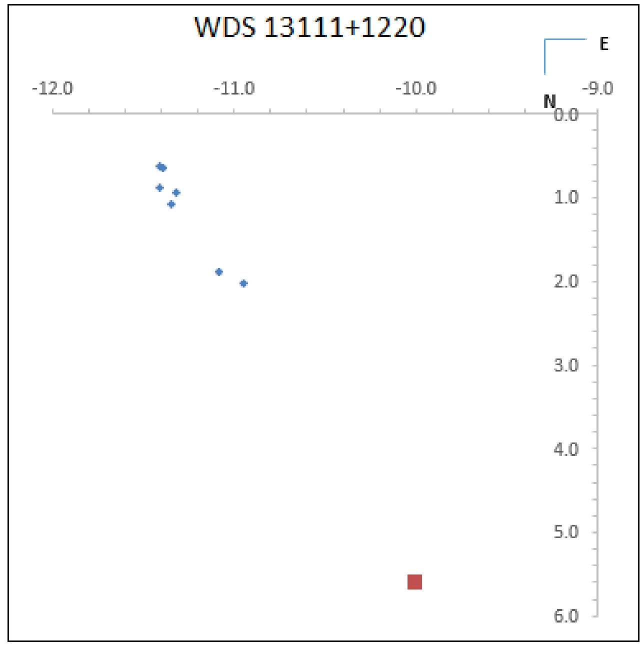

Figure 6. Historical data graphed alongside the average of the measurements presented in this paper. The gap between current and historic measurements is expected for the time passage.

Epoch	PA	Sep
1994.109	273.1	11.43
1994.09	273.2	11.41
1995.429	375.4	11.4
1995.47	374.4	11.44
1995.47	274.7	11.36
2000.33	279.7	11.24
2001.103	280.5	11.13
2019.284	299.3	11.5

Table 3. Historical measurements for OSO 51 AB with Theta and Rho from this paper.

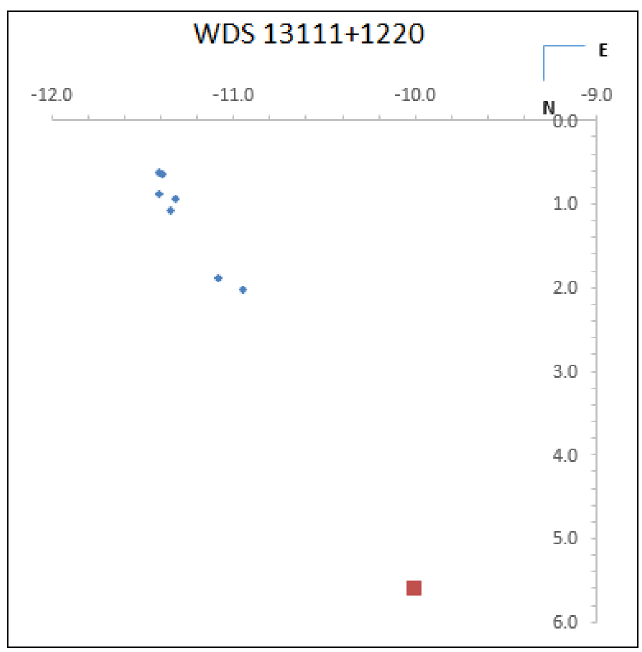

Figure 6. Historical data graphed alongside the average of the measurements presented in this paper. The gap between current and historic measurements is expected for the time passage.

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sonable as the average of the group's data lined up well with historical data, Figure 6.

Discussion

With the historical and current data sets combined, a seeming linear trend was observed, Figure 7. Figure 8 was used as a comparison between a polynomial trend and a linear trend. After comparing a linear trend and a polynomial trend, the polynomial trend had a slightly lower error by 0.0018, but the difference between the linear and polynomial trends was so minimal, that it was decided that, it is likely a linear trend, or possibly a nonlinear trend that we do not have enough data to see. With current measurements, it was observed that the system most likely was not a binary system. In the 2019 measurement, the position angle, Theta, increased, relative to historical data, Table 3. Graphing all measurements of Rho, Figure 9, the overall trend is consistent over time (shown with the most recent data point). Given that there is only 25 years of history, conclusions could be premature, but only further measurements in the future could prove or disprove any further theories. Relative to the primary star, the secondary star appears to be following a linear path. Without a sign of an arc, the trend line suggests the possibility that these stars are not binary.

In Aladin10, Figure 1, the proper motion vectors, displayed from GAIA data, are visible for each star. It is further suggested that the stars may not be gravitationally bound as the paths are divergent, given that the error estimate for RA was 0.02196 and the error estimate for DEC was 0.02264. Adding GAIA data for parallax, the primary star's parallax was 2.813. However, because of the low precision of GAIA's instruments, this figure may not be significant. The secondary star's parallax was 5.294, as shown in Table 4. Converting to lightyears (and parsecs) from Earth, the primary star is approximately 1158.89 lightyears, or 355.49 parsecs from Earth, while the secondary star is approximately 615.83 lightyears, or 188.9 parsecs from Earth, Table 5. Noting the stars' separation from each other, and lack of parallactic overlap, this adds to the belief that OSO 51 AB is an optical double, and not a gravitationally-bound physical binary.

Conclusion

The star system, OSO 51 AB, was studied to study whether a double star or gravitationally bound system. After independently collecting data, the average position angle was 299.33° and the average separation was 11.5". These measurements were compared alongside historical data, and it was seen that the position angle changed while the separation remained relatively con-

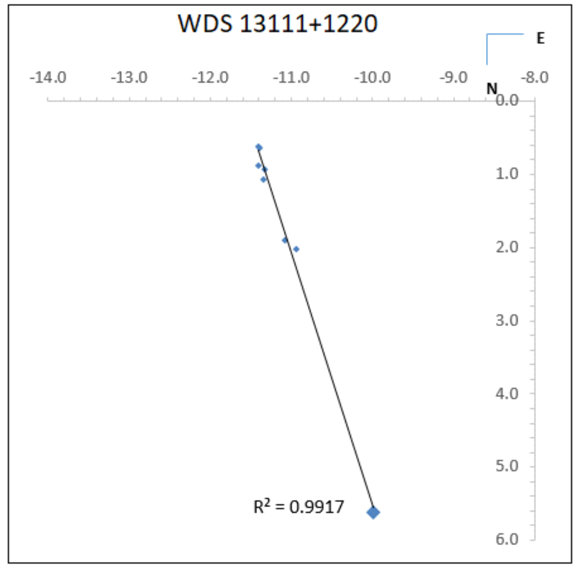

Figure 7. Historical data with average of new data along with linear trend line.

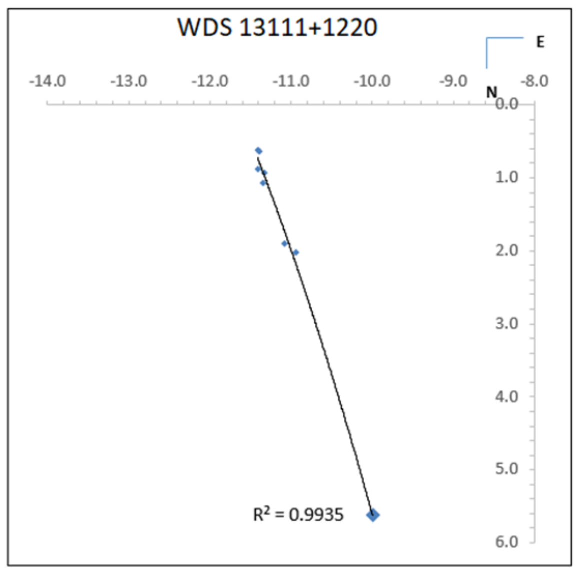

Figure 8. Historical data with average of new data along with polynomial trend line.

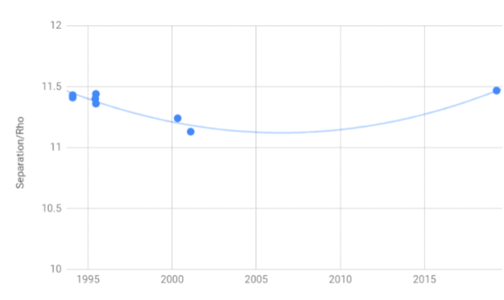

Figure 9. Graph showing Rho decreasing and then increasing over time.

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Inputs	Parallax	Parallax Error
Star A	2.812	0.025
Star B	5.294	0.216

Table 4. Parallax and parallax error for OSO 51 AB.

Star	Min Distance	Midpoint	Max Distance
Primary	352.31	355.49	358.72
Secondary	181.49	188.9	196.95

Table 5. Distance from Earth for the primary and secondary stars expressed in parsecs.

stant. The addition of the European Space Agency's Gaia archives parallax data seems to support the position that these are not gravitationally bound stars based on a parallax assessment. After considering multiple factors, it is proposed that OSO 51 AB is most likely not a physical double.

Acknowledgments

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This work has made use of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.

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