Astrometric Measurements of Double Star ARA 77

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Abstract

We performed our study on WDS 14415-1712 (ARA 77) using the Las Cumbres Observatory telescope network (LCO) to obtain our images. The intention for the candidate was to determine its probability of being a binary pair. Our measured mean Theta and Rho of 110.49° and 10.05" were complementary to prior measurements. Analysis of the system's figures from historical data and test images indicate the candidate cannot be binary.

1. Introduction

WDS 14415-1712 (ARA 77), Figure 1, has 6 recorded measurements in the Washington Double Stars Catalog (WDS) (Mason, 2012). The first of which was made in 1905 upon the system's discovery by S. Aravamudan. Both the Primary and Secondary stars share a low magnitude of 14.4, according to the WDS, thus challenging the ability of our equipment. The candidate was selected to not only evaluate the probability of being a binary pair but also to test the capability of our systems when analyzing dim double stars. Other characteristics of the pair proved interesting, specifically the variation in proper motions of the two stars. Unlike the WDS and GAIA catalogs, SIMBAD provided no information regarding ARA 77.

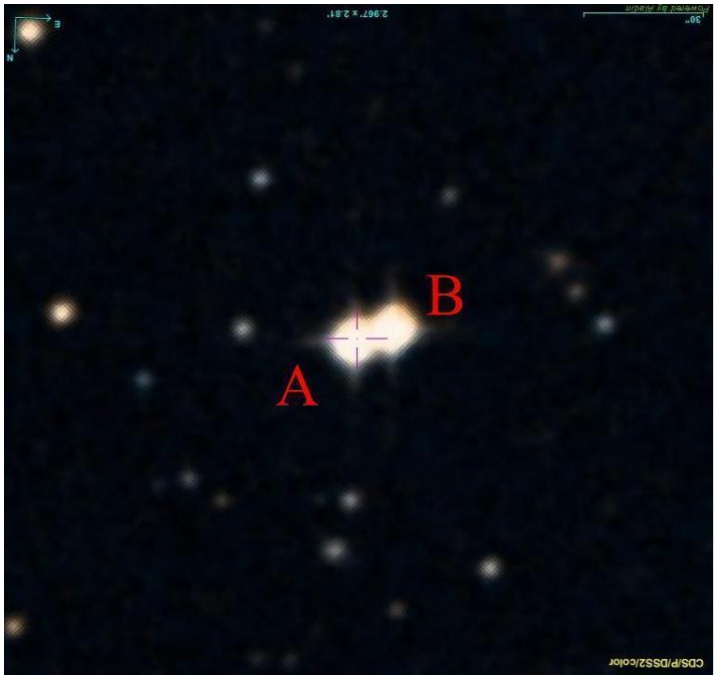

Figure 1: image of Candidate pair taken on Aladdin 10.

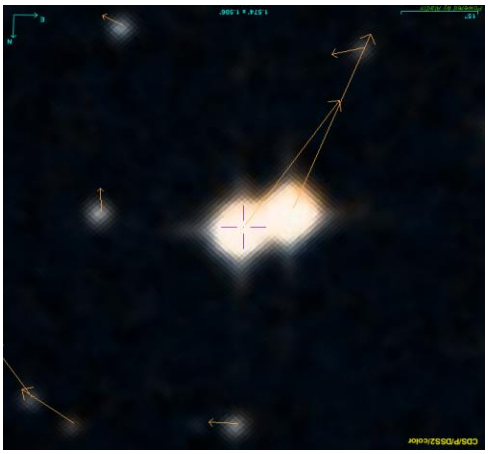

Figure 2: The A and B stars have noticeably different proper motions represented by the yellow arrows in the Aladdin 10 image.

2. Methods and Materials

The images were taken using the Las Cumbres Observatory (LCO) system. The telescope used for observations was located at the Teide observatory in Tenerife, Spain. The telescope used was the 0.4-meter reflector with a SBIG 6303 CCD camera with 8 filter options, and a FOV of 29.2 x 19.5 arcminutes. The LCO 0.4-meter reflector telescopes have been deployed all around the world with ten in total.

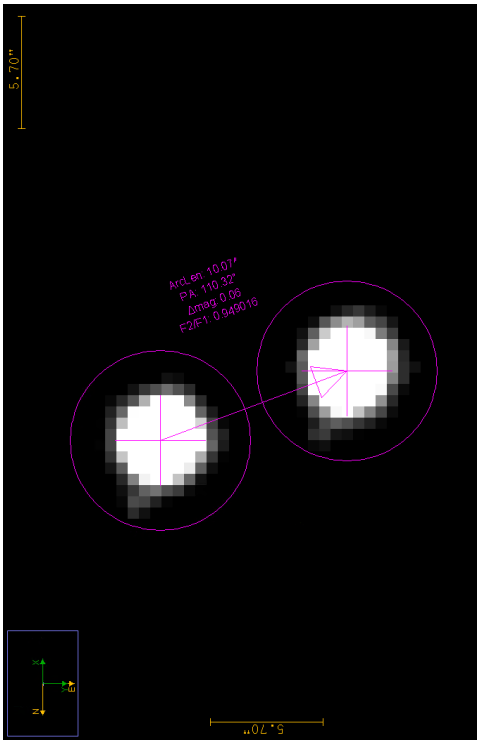

Figure 3: AIJ measurements of 14415-1712

3. Observations

A total of 12 images were taken, of which one proved too poor of quality to measure and was therefore excluded from the calculations and measurements. Due to the low magnitude of each star, our exposure times were in the range of 300 to 400 seconds. The Images were calibrated, and plate-solved by the OSS Pipeline (Fitzgerald, 2018). They were measured using AIJ software, Figure 3, and placed in an Excel spreadsheet for statistical calculations.

WDS 14415-1712 ARA 77 Astrometry				
Telescope: (number of images used in each filter)	Epoch 2021.347	Position Angle	Separation	Delta Magnitude
R Sloan (11 used), 12 images total	Mean	110.5°	10.05"	0.05
	standard deviation	0.081°	0.016"	0.006
	standard error of mean	0.02°	0.005"	0.002
Measurement 2015 (Last measurement before this observation)		109.59°	10.041"	0

Table 1: Recorded measurements and accuracy of theta, rho, and delta magnitude for ARA 77.

4. Results

The calculated mean, standard deviation, and standard error of mean for position angle, separation, and delta magnitude of ARA 77 AB are in Table 1. These measurements are nearly identical to that of GAIA's DR2 (Salgado, 2017) and the WDS. With respect to magnitude measurements, GAIA reported a primary magnitude of 12.2 and a secondary magnitude of 12.3, in Sloan g, whereas the WDS reported 14.4 magnitude for both the A and B star.

WDS 14415-1712 ARA 77 Historical Data						
Epoch	1905.35	1916.26	1999.45	2000.48	2010.5	2015
Position Angle	108.4°	103°	108.9°	109.5°	110.2°	109.59°
Separation	10.24"	9.79"	10.06"	10.11"	10.07"	10.04"

Table 2: The measured theta and rho recorded from all prior observations of ARA 77.

5. Discussion

There was minimal change in separation and position angle in the observations, closely following those of previously recorded measurements as seen in Table 2. The Harshaw statistic calculator (Harshaw, 2014), evaluates a pair's likelihood of being binary or optical based on the proper motions, Figure 2. As such, the most recent proper motion and separation measurements for ARA 77, from GAIA, indicates the pair has a vector difference of 0.354. This figure is moderately low suggesting a plausible yet still-uncertain chance of the pair being binary.

The small angle approximation was applied to the parallax measurements of the A and B stars to calculate a minimum possible separation of 4904.02 AU or 0.077 Light years. This falls well within the generally accepted 1 light year maximum separation for a pair to be gravitationally related. However, this measurement only evaluates the pair on a two-dimensional plane. When taking into account the 3rd dimension, that being the pair's radial separation, a vastly different separation is found.

Evaluating each of the star's distances from Earth proves that the small angle approximation is nothing more than a mere illusion and provides a full understanding of the space between Star A and Star B. Star A has a measured parallax of 2.0245 with an error of 0.015 and Star B has a measured parallax of 2.4358 with an error of 0.0152. When applying those values to a parallax calculator to find the radial separation it was discovered that the difference in distance is at least 1330 light years, which is far too great for the stars to be physically bound. The probability of Star A and Star B being within 1 light year was calculated to be 0%. With the distance between Star A and Star B exceeding one light year it makes the chance of the pair having a gravitational relation extremely improbable based on the aforementioned rule of maximum separation. However, keep in mind that parallaxes below 5 mas are an area of great uncertainty in measurements.

6. Conclusion

With all the measurements and calculations conducted on ARA 77, the data provided suggests that the pair is a U code system, as defined by the WDS, meaning, the discrepancy of the two star's proper motions suggest that the pair is non-physical. Additionally, certain characteristics of the pair, namely the variation in radial separation of the stars, seen on GAIA and in historical data received, make the probability of ARA 77 being gravitationally bound highly improbable. These findings among others indicate that the pair can be classified as a U code system and that ARA 77 is non-physical.

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References

Harshaw, Richard., 2014, “Another Statistical Tool for Evaluating Double Stars”. Brilliant Sky , *Journal Of Double Star Observations*

Fitzgerald, M.T., (2018, accepted), "The Our Solar Siblings Pipeline: Tackling the data issues of the scaling problem for robotic telescope based astronomy education projects". *Robotic Tele scopes, Student Research and Education Proceedings.*

Mason, Brian., et al, 2012, “Washington Double Star Catalog, Astronomy Department”, United States Naval Observatory, http://ad.usno.navy.mil/proj/ WDS/

Salgado, et al., (2017): Gaia Data Release 2. Gaia achive data access facilities; European Space Agency (ESA) mission Gaia, https://www.cosmos.esa.int/ web/gaia.