Astrometric Measurements of Double Stars LEP 57 and LDS 1317

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Abstract: We performed astrometric measurements of the AB (LEP 57) and AC (LDS 1317) pairs of star system WDS 12323+1335 using images taken with the Las Cumbres Observatory (LCO). We used a 0.4-meter Meade telescope to investigate both pairs. For LEP 57, we aimed to validate the existence of the neglected and rarely observed B star, which had not been measured since epoch 2000. The images taken indicated that the B star may not exist, and that the two previous measurements of the AB pair are unaccountable. For LDS 1317, a mean Theta and Rho of 351.2° and 12.5" respectively were calculated. The AC pair is likely physical.

Introduction

Double Star WDS 12323+1335, Figure 1, is a double star system with recorded observations of an AB, LEP 57, and an AC pair, LDS 1317. LDS 1317 was first discovered in 1962 as a two-star pair with a separation of 13". In 1998, another observation found a new star at a separation of 5.23". This new star replaced the original B star, and the original B was relabeled as the C star (Mason, 2012).

The system was initially chosen as a research target due to LEP 57 having only two observations with the last occurring in 2000, by Sebastien Lepine. His observation reports that the system is a triple star and includes position angle and separation measurements for LEP 57. LDS 1317 has seven unique observations in the WDS and was last observed in 2015 as part of a GAIA sky survey. A review of the pair's records in GAIA additionally showed consistently similar proper motion (PM) measurements, Figure 2.

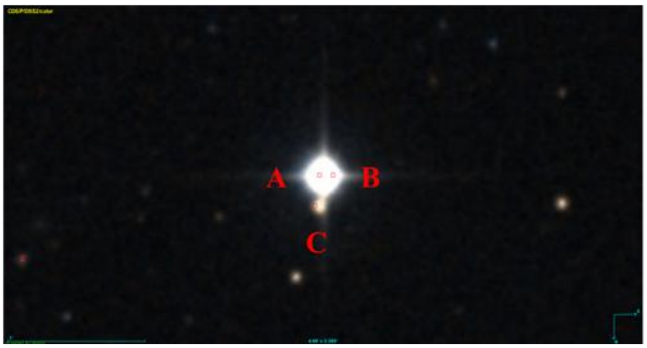

Figure 1: Aladin 10 image of system 12323+1335 as well as the predicted location of the B star.

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Locating the B star of LEP 57 through Aladin 10 proved difficult, and the focus of the research was thus shifted from simply updating older data to further exploring the existence of LEP 57 AB and consequentially updating the data if the AB pair indeed existed. Additionally, LDS 1317 would be analyzed to determine if it was a binary pair or simply an optical pair.

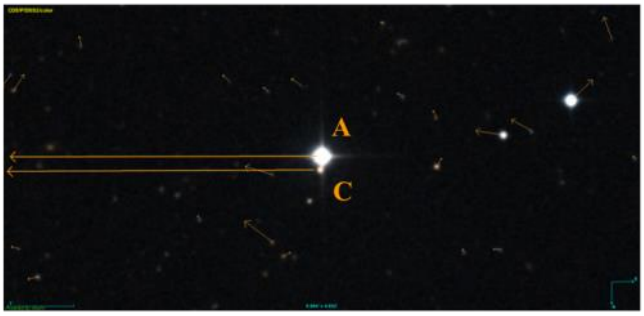

Figure 2: Both the A and C star have very high and very similar proper motion, as seen in Aladin 10 with a GAIA proper motion overlay.

Methods and Materials

Equipment

The images were taken using the Las Cumbres Observatory (LCO) system. The primary telescope used is located at the McDonald Observatory in Texas, and additional images were taken from the Haleakala Observatory in Hawaii, USA. Both presented a minimal air mass value at the scheduled observation angle. Each telescope has eight filters, a 29.2 x 19.5 arcminute FOV, and an SBIG STL-6303 CCD camera.

Analysis of an Unmeasured Component of WDS 12290+3735 KZA 36

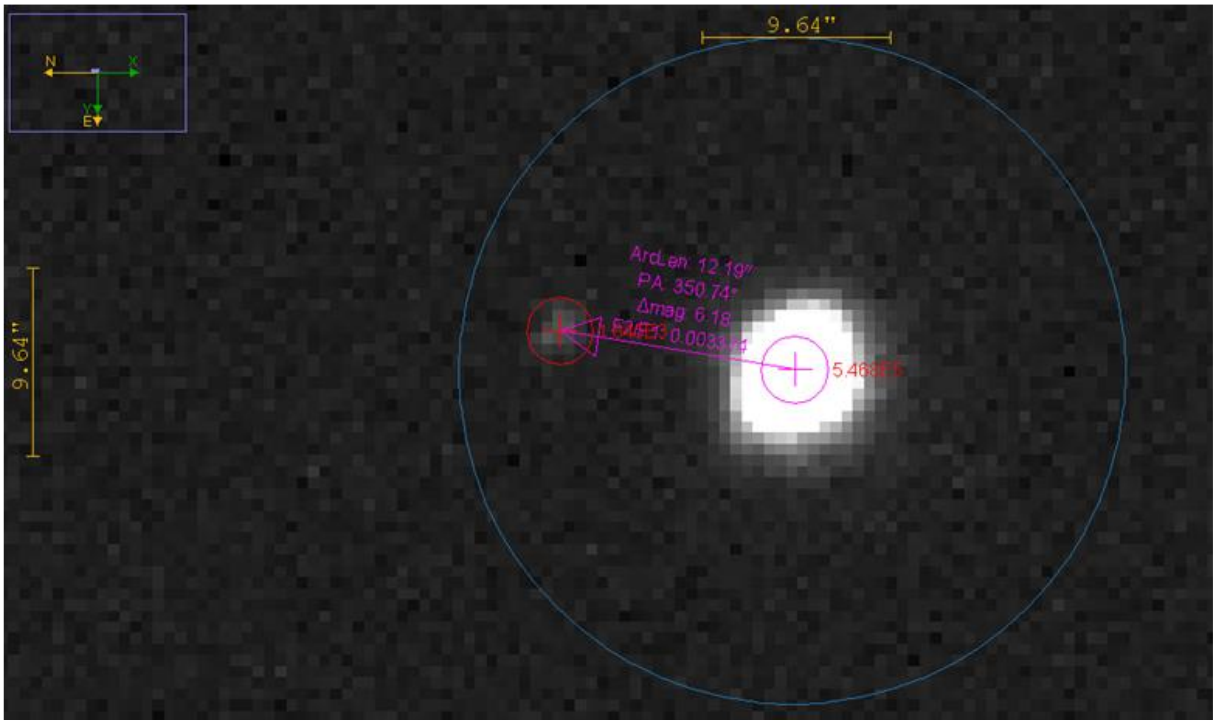

Figure 3: AIJ Image showing LDS 1317 AC.

Observations

A total of 16 images were taken using the Pan-STARRS-w filter on April 18th, 2020 with four different exposure times: six, eight, ten, and twelve seconds. Both the Hawaii and Texas observatories were used.

The images were processed through the Our Solar Siblings (OSS) Pipeline. The OSS Pipeline (Fitzgerald 2018) processes images in multiple phases by cleaning, labelling, plate solving, and calibrating all images to optimize them for later analysis. After OSS Pipeline processing, images were measured with AstroImageJ. The Distance & Angle tool was used to accurately locate the stellar center of each star, and measure the position angle and separation. Once all measurements were made, data was organized in an excel spreadsheet to determine mean values as well as standard deviation and standard error of the mean for the complete image set.

Results

Table 1 displays our calculated mean position angle (Θ) and angular separation (ρ) of LDS 1317 AC, as well as the standard deviation and standard error of the mean for the pair. The delta magnitude was also measured, and the mean of these measurements was calculated at 6.1935. It was not possible to measure LEP 57 AB, as the B star was unobservable in all images and using all filters.

Discussion

AB Pair

In the images acquired, the B star was not visually discernible within or around the previously reported separation of 5.23" from the A star while using the Pan-STARRS-w filter. Four images were also taken using the Sloan r filter, which includes some of the infrared spectrum, and yet the B star was not visible in those images either. Additionally, the area around the A star was examined for signs of a B star within a 30" radius. As there were no prior measurements of the B star's proper motion, it was impossible to perform a more accurate search, and no candidate was found with similar magnitude to the B star in the immediate area.

In addition to it not being present in our images, GAIA was unable to perform a parallax measurement of the B star nor identify any viable star within proximity of the A star. DSS images show that the A stars magnitude of 9.92 V and angular radius of ~6.5" are great enough to feasibly obstruct view of the B star entirely. When using a data layer provided by the NASA/IPAC Extragalactic Database (NED) while observing the system in Aladin 10, it was found that an infrared source is recorded to be in the exact location of the B star's last known position, Figure 4. In WDS, the B star has a "K" note on it, indicating that it's magnitude was measured in the infrared band. Additionally, 2MASS, a

Analysis of an Unmeasured Component of WDS 12290+3735 KZA 36

WDS 12323 + 1335 LDS 137			
Telescope(number of images taken per exposure count using the W filter	**Epoch:2020.297**	**Θ(Degrees)**	**ρ(arcseconds)**
kb 88:(4,6 sec),(4,8 sec) kb 82:(4,10 sec),(4,12 sec)	Mean:	351.200	12.334
	Standard Deviation:	1.007	0.101
	Std. Error of Mean:	0.252	0.025
2015.15 (Last measurement prior to this investigation)		351.201	12.571

Table 1: Table displaying filters used and the calculated average values of our measurements.

sky survey using a filter within the infrared spectrum, has a record of the B star, and is responsible for its only magnitude measurement of 14.3 using the H filter. Due to a lack resources it was impossible to make a recording in the infrared band, but it was noted that as the angular radius of the A star is greater than the separation of the B star, it's possible the B star would have been impossible to observe, even when using an infrared filter. Considering the lack of consistent information on the B star as well as the uncertainty of its physical status according to multiple unique sky surveys, there is not enough evidence to confirm the existence of the B star.

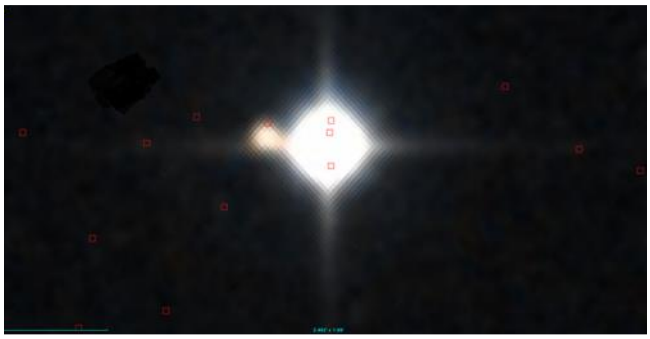

Figure 4. Aladin 10 image of system 12323+1335 taken through the NED database.

LDS 1713 AC

Epoch:	Θ(°)	ρ(arcseconds)
1962.22	352.0	13.000
1998.04	351.3	12.380
2000.00	351.7	12.300
2001.10	351.0	12.465
2012.40	352.1	12.470
2015.00	351.2	12.516
2015.50	351.2	12.517

Table 2: Historical WDS measurement data of the AB pair.

	Parallax	Error
Star A	12.6031	0.0671
Star B	Not Reported	Not Reported
Star C	12.5329	0.0508

Table 3: Measured parallax values of system 12323+1335, note the lack of data for the B star due to its invisibility.

AC Pair

The measurements made of LDS 1317 are consistent with those made previously, seen in Table 2. The most recent observation, a GAIA measurement for epoch 2015.5, recorded LDS 1317 with a Theta and Rho of 351.2° and 12.5" respectively, both being well within the margin of error relative to the measurements made by our group. With values this similar to the records, our Theta and Rho measurements appeared to be accurate and reliable. A review of the parallax for both showed a similar measurement of 12.6031 for the A star and 12.5329 for the C star, Table 3.

The Harshaw Statistic Calculator (Harshaw, 2014) was used to analyze the proper motion measurements of the A and C star, and quantify the vector difference between the two. In Harshaw's paper, he states that there is a clear association between low vector differences and gravitational pairs, so a pair with a low vector difference, for example a value of 0.1, is likely to be a physical pair. When the two proper motion measurements of the AC pair were entered, the result was a vector difference of ~0.005, an extremely low value. With such a slight vector difference, it's likely that the A and C stars are a physical pair.

The parallaxes of the A and C stars were used to calculate the minimum separation distance between them. By applying the small angle approximation, their minimum separation at the time of our observations was 0.155 light years perpendicular to our line of sight.

The difference in the mean distance to the A and C stars in the radial direction from the Gaia DR2 data is 1.45 light years. The errors in these measurements are relatively small due to the nearness of these two stars, roughly 80 parsecs. There are competing views on the maximum spatial separation allowed for two stars to be gravitationally bound: one light year and three light years depending largely on their masses. We employed Buchheim's method of determining the probability density function of their separation in the radial direction based on the Gaia data. We found that there is a 32% likelihood that A and B are within one light year of each other and 81% likelihood of being within three light years apart radially.

Previous records of LDS 1317 AC support the possibility that the system is a physical pair, and our measurements supported their physical status further. With highly similar proper motion and parallax in addition to the close separation of less than 13" that has persisted since 1962, it is highly likely that LDS 1317 is a physical pair. Additionally, our calculations of the vector differences and probability of gravitational relation are highly reliable, tested methods that continue to support the proposition that LDS 1317 AC is a physical pair.

Conclusion

From the observation, two conclusions were formed about this star system. First, for LEP 57, it was determined that the B star couldn't be confirmed. Overall, the recorded data of the B star was generally limited, likely due to the luminosity of the A star, which restricted data gathering on the B star. There was also some conflicting data on the arc-second separation for the closest star to the primary star. For example, SIMBAD stated that the separation of LEP 57 AB was 5.23", but the GAIA catalog shows that the closest star is 12.5" away, the separation value of the C star. In addition, the 2MASS sky survey was able to detect the B star using an infrared bandwidth filter, yet it is the only source to do so. The search for the B star did not reveal any other star resembling it from the previously recorded 5.23" or 30" radius around the primary star. Because of all these past issues and our inability to get a clear image of the B star, it wasn't possible to confirm the star's existence or its lack thereof.

Regarding LDS 1317, we concluded that there is a high probability that the AC pair is a physical pair. The last observation and documentation on the AC pair before we started our research was performed by GAIA in 2015. Both of these stars have a very similar parallax with parallax measurements of 12.6031 for the A star and 12.5329 for the C star. Using the Harshaw Statistic Calculator to analyze our proper motion measurements, the resulting and extremely low vector difference value of ~0.005 is a factor in determining the gravitational relation of the A and C stars. This shows us that they are moving together which supports the assumption that the AC pair may be gravitationally related. Finally, we calculated that there is a 32% probability that this pair is within one light year of each other in three dimensional space, and an 81% chance that they fall within a three light year distance, indicating a significant chance that they are gravitationally bound. This myriad of evidence leads us to conclude that LDS 1317 AC is most likely a gravitationally bound pair.

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