Astrometry of HLN 15 AB,C

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Abstract

Using images from the LCO Cerro Tololo Telescope, measurements were made of the star system HLN 15 AB-C in order to determine the existence of gravitational attraction between the 3 stars in the system. We determine that it is unlikely that the C star is gravitationally bound to the AB pair using historical data and computations made with proper motion

1. Introduction

The purpose of this paper is to provide additional measurements for WDS 10292-6031 HLN 15 AB-C. Our objective is to discover evidence for or against a gravitational attraction in the system. Only four prior measurements had been made before our measurement over the past 54 years.

HLN 15 was selected as our system utilizing the following criteria: separations between 5 and 12 arcseconds, primary magnitude greater than 11, delta magnitude lower than 3, and lack of observation since 2000. Since it was selected, it met all the criteria.

Our system was discovered in a combination of the first two measurements. In 1929, Morris K. Jessup discovered the A and B components of our system using the University of Michigan Lamont-Hussey Observatory located in South Africa and labeled the system as JSP 395 AB. In 1968, Walter Holden used the same telescope and discovered the C star. With the addition of the C component, it was designated as HLN 15 AB-C. The last observation made of HLN 15 was in 2000. A summary is shown in Table 1.

Table 1. Last Measurement of HLN 15

System Identifier		Last Meas.		Theta		Rho		Magnitude		Proper Motion 1&2		Precise Coords
		First	Last	First	Last	First	Last	Pri	Sec	RA" Dec"	RA" Dec"	
10292-6031HLN 15AB,C		1968	2000	177	183	7.3	7	10.12	13.1	+004 +003	-013 -029	102912.69-603103.8

2. Equipment & Methods

We used the Las Cumbres Observatory (LCO) network's Cerro Tololo telescope (Brown, 2013) to image HLN 15, Figure 1. The LCO images were calibrated, and plate solved, by the Our Solar Siblings (OSS) pipeline (Fitzgerald, 2018). They were then analyzed with AstroImageJ (AIJ) and its imbedded astronomic measurement tool. This tool provides a relative delta magnitude, apparent separation, and position angle, Figure 2.

Figure 1: Image of Cerro Tololo telescope used to image HLN 15

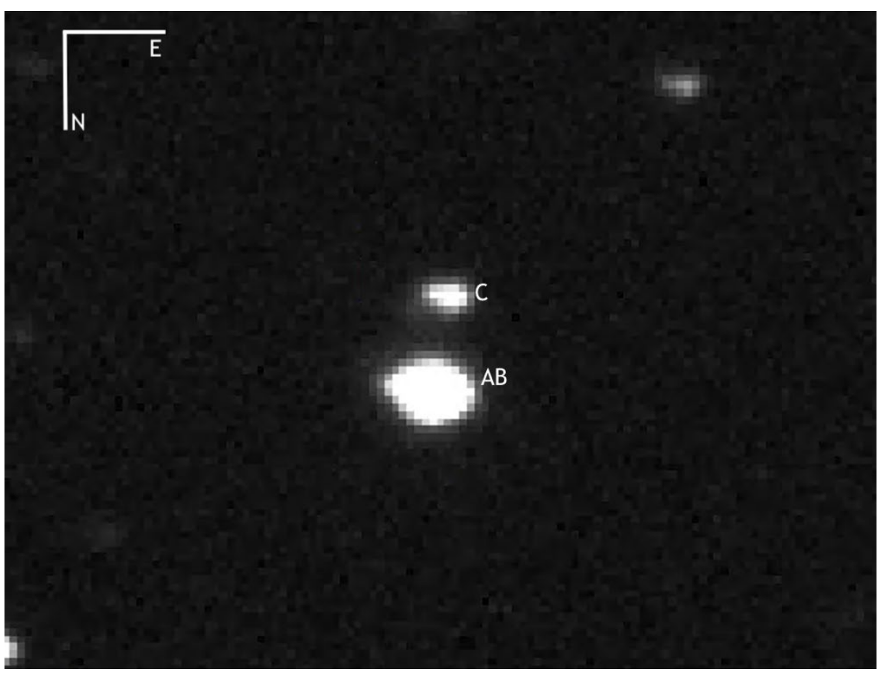


Figure 2: Image of HLN 15 taken by LCO telescope system. 'AB' shows the A and B stars while 'C' shows the C star

The AIJ measurements were recorded in an Excel tool that automatically calculated the mean and standard deviation of our set of data. This tool was provided by Boyce Research Initiatives and Education Foundation (BRIEF). We proceeded to use a Harshaw Statistic Calculator to determine the likelihood of the pair being gravitationally bound (Harshaw, 2014). Additionally, to help identify evidence of a pattern in the historical movement of the components, we used another Excel plotting tool that created a graph from the Washington Double Star Catalog (WDS) data, also given to us by the BRIEF.

3. Data

3.1 Telescope Measurements

The total number of our observations and further information regarding the telescope operation is compiled in Table 2. The AIJ measurements and Excel statistics are compiled in Table 3 along with standard deviation.

Table 2. Telescope Observation

Observation	Julian Date	Filter	Exposure Time
1	2022.3231	SLOAN r	13 seconds
2	2022.3231	SLOAN r	11 seconds
3	2022.3231	SLOAN i	12 seconds
4	2022.3231	SLOAN i	16 seconds
5	2022.3231	SLOAN g	5 seconds
6	2022.3231	SLOAN g	6 seconds

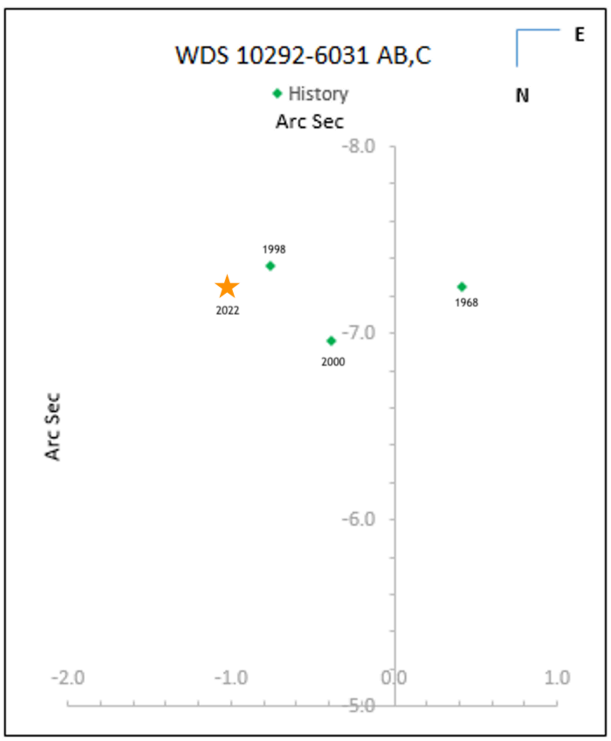
Table 3. Basic Measurements and Statistics

WDS Number: 10292-6031		Discoverer Code: HLN 15 AB,C			
Filter	Position Angle		Separation		Delta Magnitude	
	Mean	Deviation	Mean	Deviation	Mean	Deviation
G	188.492	0.67	7.427	0.057	3.242	0.098
R	188.104	0.141	7.298	0.033	3.205	0.016
I	187.329	0.289	7.223	0.051	7.223	0.051
Epoch		Theta		Rho		
2022.317		188		7.3		

3.2 Historical Data Graph

Using the historical data provided by the USNO and Harshaw's Plot Tool (Harshaw 2014), we created a graph of the historical data, Table 4. The date for each measurement is provided. No obvious pattern can be seen from point to point.

Table 4. Historical Graph of Measurements



4. Discussion

4.1 Separation and Distance

Using resources such as Simbad, GAIA, and Aladin 11, we were unable to find distance information on the AB component. However, proper motion was provided in the WDS via the UCAC4 Catalog (Dr. R. Matson, personal communication, October 17, 2022). Additional information such as parallax, temperature, and stellar class were also not reported for this pair. Figure 3 highlights the data that has not been measured in Aladin 11 (Bonnarel, 2000)

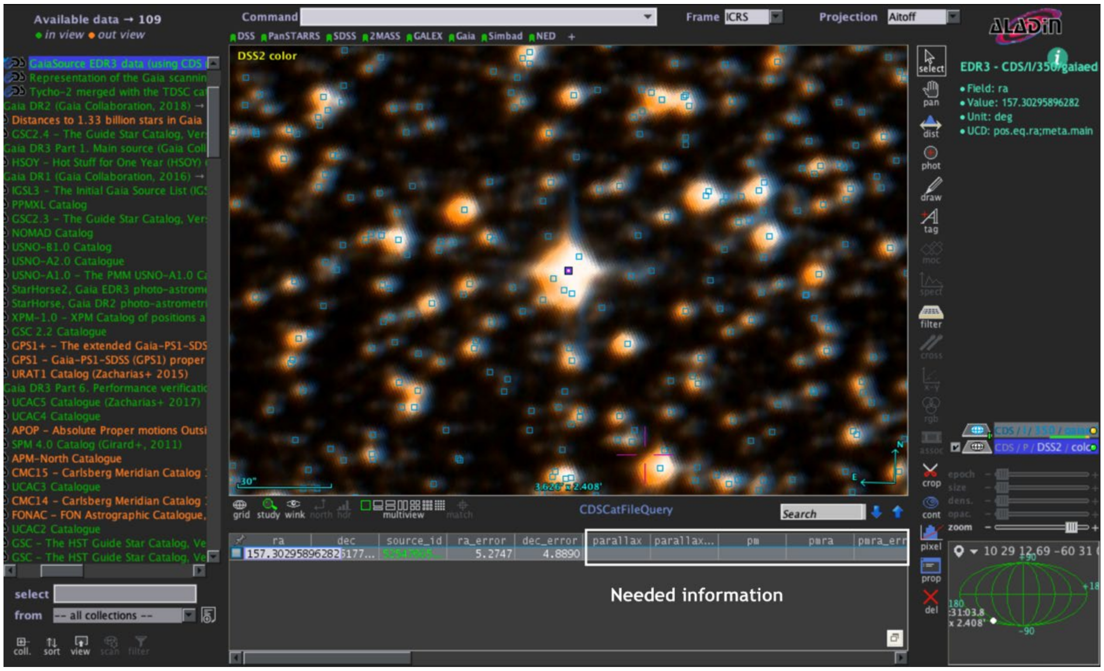


Figure 3. Screenshot of Aladin's Gaia data on our system, boxed and labeled in white is the missing information that we need.

Despite the limited data on the AB pair, we were able to calculate the separation between the components AB and C. As seen in Table 3 we approximate the separation to be around 7.3''. This separation was calculated using our telescope images and AIJ's measure tool as explained in section 2.

4.2 Proper Motion

Over the course of investigating this system, we identified three separate proper motion measurements for both the AB and AB-C systems between the WDS and GAIA catalogs. In the WDS (Figure 5) JSP 395 AB (the AB component of HLN 15 AB-C) only reports motion for the Primary (A) of this AB system. For HLN 15 (AB-C) the proper motion reported for the AB from JSP 395 does not match the primary (AB) of HLN 15. Additionally, for HLN 15 proper motion for the Secondary (C) is reported, but this value differs from GAIA. Therefore, Figure 4 only has the proper motion vector coming from the C component. The most probable reasons are that the AB pair were unresolved in the GAIA catalog, and that we are looking at data collected over several decades during which technology changed and improved, and thus a measurement was not provided.

With respect to the differing proper motions for JSP 395 and HLN 15 AB components, we queried the United States Naval Observatory (USNO). The discrepancy lies in the source of measurement from the Tycho mission (Dr. R. Matson, personal communication, October 17, 2022). The entire system was measured again during the UCAC4 mission (Dr. R. Matson, personal communication, October 17, 2022). Both of these measurements are on the WDS and are compared in Figure 5.

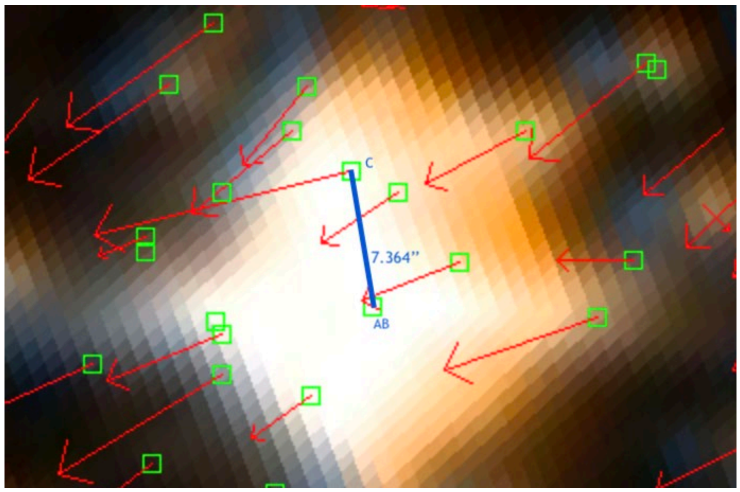


Fig 4. Proper Motion image of HLN 15 from Aladin. There is no vector coming off the AB component. Separation labeled in blue.

10292+3718RAO 248	2015	2016	3	307	306	2.7	2.7	12.5	15.1	M0	-250-117	-264-107		V R	102912.19+371811.0
10292+1009STT 220	1843	2012	58	57	101	1.2	0.6	7.51	8.59	F8	-003-030	-003-030	+10 2160	O	102911.36+100920.0
10292-2308LDS3992	1960	2015	6	91	91	303.0	301.9	13.4	16.19		-187-004	-233-017			102912.63-230716.9
10292-4234TDS7293	1991	1991	1	229	229	0.4	0.4	10.74	10.80		-009+005	-009+005			102914.62-423414.4
10292-4626B 1157	1929	1933	2	31	31	0.2	0.2	9.8	10.0	F2IV/V	-012-019		-45 6112		102913.71-462621.3
10292-5737KRV 30	2000	2015	2	322	322	26.6	26.6	8.3	17.5		-007+002		-56 3425	N	102911.25-573648.2
10292-6031JSP 395AB	1929	2015	3	115	106	0.2	0.1	10.9	10.9		-007+001		-59 2164		102912.69-603103.8
10292-6031HLN 15AB,C	1968	2000	3	177	183	7.3	7.0	10.12	13.1		+004+003	-013-029			102912.69-603103.8
10293+4233ES 1395AB	1915	2017	11	76	79	4.4	4.4	9.46	12.14	F8	-035-021	+005-013	+43 2022	W	102918.75+423259.8
10293+3103RAO 249	2016	2016	1	346	346	0.8	0.8	12.5	14.9		+064-155			R	102918.25+310257.1
10293-3749UC 1938	1999	2016	5	338	339	8.1	8.1	12.2	15.9		-115-014	-123-006		V	102918.61-374837.6
10293-4125DAM2381	2015	2016	2	323	323	3.6	3.6	15.0	16.1		-015+011	-015+011		V	102919.36-412512.4
10294+7932LDS1713	1965	2015	9	37	39	10.0	10.7	14.6	16.2		-096-114				102924.36+793243.0
10294+1211HDS1507	1991	2020	17	44	43	0.1	0.1	7.69	8.76	F2	-069-009		+12 2217	NO	102925.66+121113.3
10294+0615A 2766	1914	2003	4	318	172	1.0	1.3	7.67	12.8	K2	-019-008		+06 2311		102921.11+061523.2
10294+0346SLE 494	2000	2015	8	37	37	22.6	22.5	13.12	13.58		+016-018	+024-011		N	102928.68+034605.5

Fig 5. Comparison of proper motion between JSP and HLN. JSP's vector is -007+001. HLN's AB PM vector is +004+003

The third measurement, for the Secondary of HLN 15 is provided by GAIA. Its measurement was -13.743 +3.451.

Since GAIA does not have proper motion for the AB component, we cannot determine a Harshaw Statistic purely using GAIA data. On the other hand, the WDS (Mason, 2018) has data for both components. It collected its data from the UCAC4 Catalog mentioned previously (Zacharias 2012). Understanding the various sources of proper motion data, and the differences contained within, we performed a Harshaw calculation using both sets of data. All of this is compiled in Table 5.

Given these best estimate assumptions, the statistic never dipped below 0.9. When using strictly WDS data just for HLN 15, the statistic remained above 0.9. This remained true when combining HLN and Gaia proper motion data as well. However, when we combined WDS JSP data and Gaia data, the statistic fell to 0.3.

Table 5. Proper Motion taken from each database and Harshaw Statistic (Harshaw 2014)

	HLN 15 AB,C Proper Motion				
	AB Pair		C Star		
	RA	Dec	RA	Dec	Harshaw Statistic
WDS: JSP	-7	1	NA	NA	NA
WDS: HLN	4	3	-13	-29	0.985178
Gaia	NA	NA	-13.743	3.451	NA
JSP + Gaia	-7	1	-13.743	3.451	0.337777
HLN + Gaia	4	3	-13.743	3.451	0.925876

5. Conclusion

We added measurements of delta magnitude, separation, position angle to the system HLN 15. Based on our observations and on the varying data available for the system, we determine that it is unlikely that the C star is gravitationally bound to the AB pair using historical data and computations made with proper motion.

6. Acknowledgements

We are grateful for Pat Boyce from the BRIEF foundation who helped us through the entire process. He taught us the entire process of gathering data and authoring this paper, and made this possible. We would also like to thank Joe Smith for being our mentor and using his experience to help us.

We thank Michael Fitzgerald who calibrated, cleaned, plate solved, and sent the LCO telescope data to us via his Our Solar Siblings pipeline. His help sped up our research process significantly.

We thank Richard Harshaw who authored and created his position plotting tool, which helped us gain a view of our system from a historical standpoint. The data that we gained from its use was critical in our conclusion.

This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory.

This work makes use of observations from the Las Cumbres Observatory global telescope network SBIG STL6303 camera on the LCOGT 0.4m telescope at Cerro Tololo Observatory.

This research has made use of the SIMBAD database, operated at CDS, Strasbourg Observatory, France. In addition, we used the Aladin Sky Atlas, also operated by CDS.

7. References

Bonnarel, F. et al. (2000) The ALADIN interactive sky atlas. A reference tool for identification of astronomical sources. Astronomy and Astrophysics Supplement, v.143, p.33-40

Brown, T.M. et al. (2013) Las Cumbres Observatory Global Network. Publications of the Astronomical Society of the Pacific, v.125, i.931, p.1031-1055

Fitzgerald, M.T. (2018) The Our Solar Siblings Pipeline: Tackling the data issues of the scaling problem for robotic telescope based astronomy education projects. Robotic Telescopes, Student Research and Education Proceedings, v.1, no.1.

Harshaw, R. (2014) Another Statistical Tool for Evaluating Binary Stars. Journal of Double Star Observations, v.10, no.1, p.32-51.

Harshaw, R. (2018). Gaia DR2 and the Washington Double Star Catalog: A tale of two databases. Journal of Double Star Observations, 14(4). Retrieved from http://www.jdso.org/volume14/number4/Harshaw_734_740.pdf

Smith, J(2020). Astrometric Measurements of WDS 06425-2314 BU 195. Journal of Double Star Observations, v.18, no.3, p.276-285 Retrieved from http://www.jdso.org/volume18/number3/Smith_276_284.pdf

Stelle Doppie (2018) 10292-6031 HLN 15AB,C https://www.stelledoppie.it/index2.php?iddoppia=47310

Mason, B., (2018) "The Washington Double Star Catalog", Astrometry Department, U.S. Naval Observatory. http://ad.usno.navy.mil/wds/Webtextfiles/wdsnewframe2.html

Wenger, M. et al. (2000) The SIMBAD astronomical database. The CDS reference database for astronomical objects. Astronomy and Astrophysics Supplement, v.143, p.9-22.

Zacharias, N. et al. (2012) The fourth U.S. Naval Observatory {CCD} Astrograph Catalog ({UCAC4}) resource provided by the {GAVO} Data Center. Retrieved from http://dc.zah.uni-heidelberg.de/ucac4/q/s/info