An Astrometric Measurement of 01589-5652 LDS 63 and Analysis using GAIA DR3 Data

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Abstract

The components of WDS 01589-5652 LDS 63 show common proper motion and are included in the Luyten double star catalog. The nature of LDS 63 was further investigated using a current astrometric measure and GAIA DR3 data. LDS 63 was imaged using the Las Cumbres Observatory (LCO) Global Network of Telescopes. Calibrated images were obtained and analysed using the software AstroImageJ to determine position angle, separation and delta magnitude. Using the GAIA DR3 data and apparent separation reported in this paper, mean, minimum and maximum distance separation was estimated. In addition, the space velocity of the primary and secondary, the angle between each of the components space velocity vectors in 3D space (Nugent metric), relative 3D space velocity, system escape velocity and $E_{binding}$ were calculated. Analysis shows that LDS 63 is at least a co-moving pair and may possibly be a binary star system.

1. Introduction

The Luyten Double Star Catalog (LDS) is a list of double stars culled from William Jacob Luyten's Palomar Survey publications.[1]

LDS 63 was first measured in 1892.89 when the position angle was 128.6° and the separation was 36.35″ (Urban et al, 1998). The last measure was in 2016.0 when the position angle was 128.5° and the separation was 36.04″ (El-Badry et al, 2021). The G magnitude of the primary is 8.01 and its spectral class is K0IV C. The G magnitude of the secondary is 8.99 and its spectral class is F8 D (https://simbad.cds.unistra.fr/simbad/).

Selected GAIA DR3 data for LDS 63 is shown in Table 1 (Prusti et. al. 2016; Vallenari et. al. 2023). From the GAIA DR3 archive, the Renormalised Unit Weight Error (RUWE) for the primary is 0.9988043 and 1.0575067 for the secondary consistent with a good astrometric fit (El-Badry, 2025).

Table 1. Selected data on LDS 63 from GAIA DR3. Stellar Luminosity and Stellar Mass data comes from GAIA DR3 FLAME.

WDS Identifier 01589-5652 LDS 63	**parallax ± 1σ mAS**	**Total proper motion ± 1σ mAS/yr**	**pmra ± 1σ mAS/yr**	**pmdec ± 1σ mAS/yr**	**DR3 radial velocity ± 1σ km/sec**	**Luminosity SolLum Mass M⊙**
A Component Gaia source id: 4718502477850718720	7.5799 ± 0.0158	187.675 ± 0.017	137.703 ± 0.017	127.514 ± 0.017	7.68 ± 0.12	9.62 1.53
B Component Gaia source id: 4718501721936475136	7.5755 ± 0.0120	187.896 ± 0.013	137.693 ± 0.013	127.850 ± 0.013	7.81 ± 0.14	3.28 1.24

[1] The Luyten double star catalog may be accessed at https://vizier.cds.unistra.fr/viz-bin/VizieR?-source=I/130

The distance from the Sun to the primary and secondary of LDS 63 with 1σ parallax uncertainties is shown in Figure 1. The distances from the Sun to the primary and secondary show overlap.

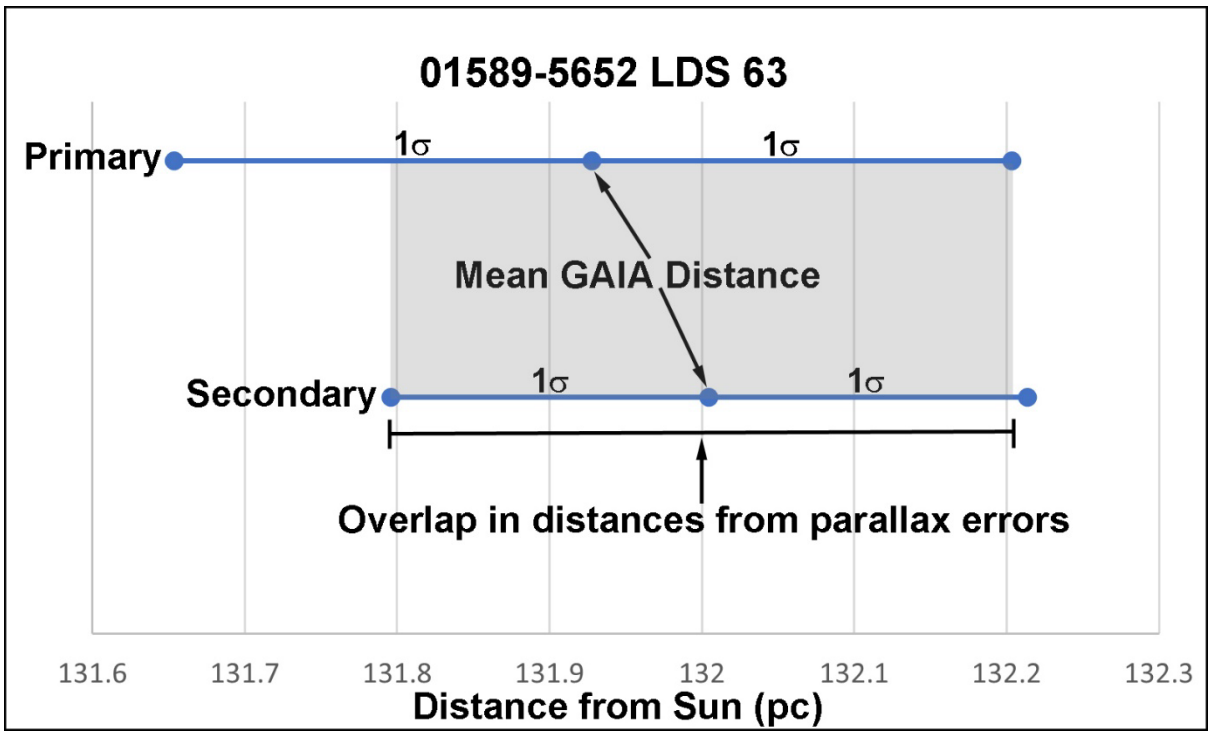

Figure 1: GAIA DR3 distances of the components of LDS 63 from the Sun including 1σ parallax errors

2. Methods

Using the Las Cumbres Observatory Global Telescope Network, LDS 63 was imaged on October 31, 2025 and December 12, 2025 (Mean Decimal Date: 2025.889; Mean JD UTC: 2460993.595) at Cerro Tololo Inter-American Observatory with a Planewave Delta Rho 350 telescope and QHY600 CMOS camera system. The camera format was 9576 x 6388 pixels, 3.76 micron pixels size. Field of view 1.9 degrees x 1.2 degrees readout mode full-frame, 30'x30' in readout mode central 30x30. Pixel size (1x1 binning, arcsec) ~0.74"/pixel, default binning 1 x 1, read noise (e-) ~ 3 to 3.5 e- and gain (e-/ADU) 0.7 e-/ADU.

Twenty images were taken on October 31, 2025 and ten images were taken on December 12, 2025. The images were recorded through a Bessel-V Filter and the exposure time for each image was 2.9 seconds. The air mass was 1.1 and 1.2 for each set of images respectively. The calibrated images were individually inspected for quality and all were subsequently chosen for analysis. The images were analysed using AstroImageJ with apertures set at 7 pixels (object aperture), 10 pixels (inner radius of background annulus) and 14 pixels (outer radius of background annulus), Figure 2, and mean value, standard deviation and standard error of the mean determined for position angle, separation and delta magnitude, Table 2.

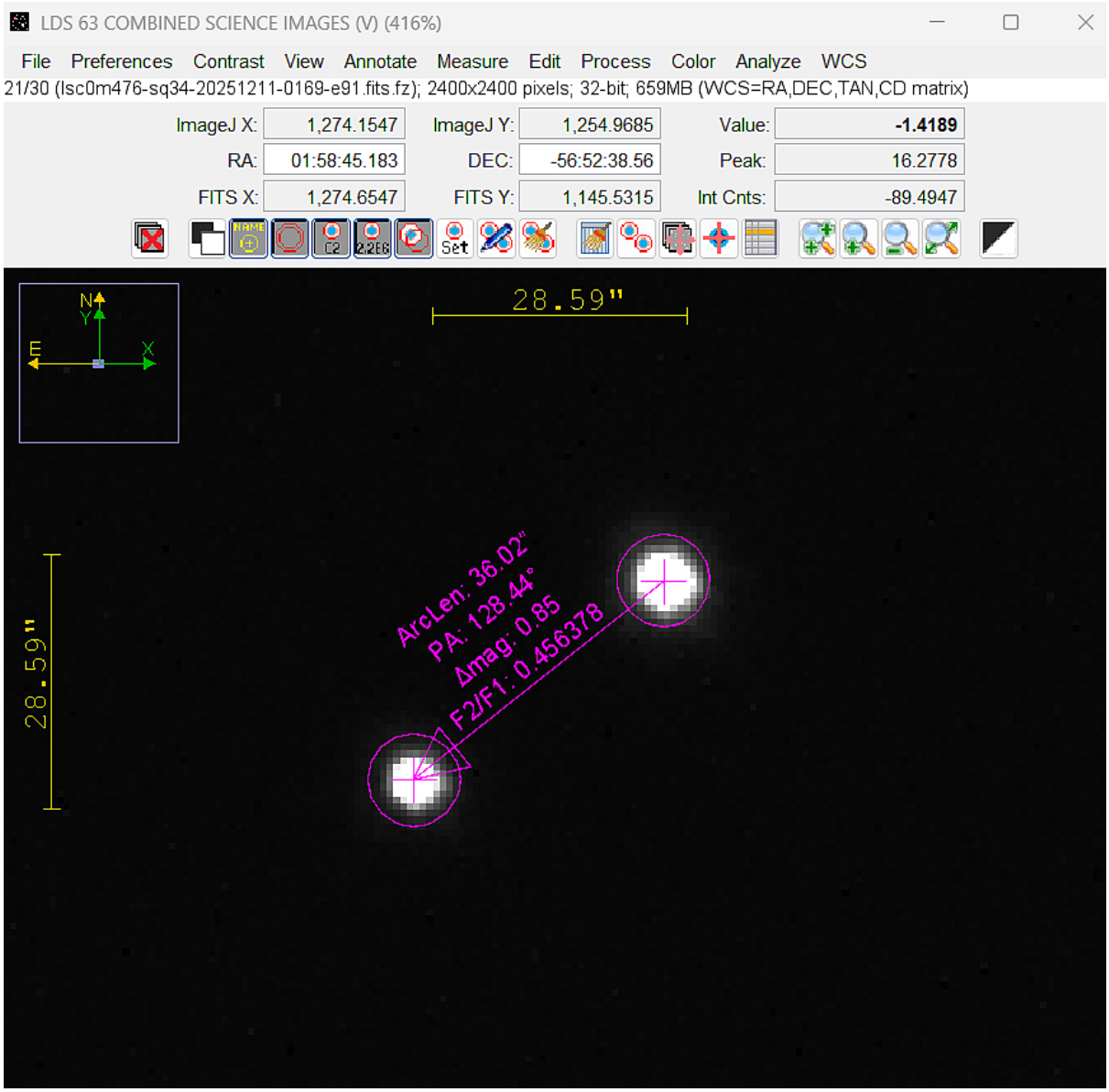

Figure 2: Representative image of LDS 63 analysed with AstroImageJ showing separation, position angle and delta magnitude

To calculate D, the mean physical separation distance of the components in pc, the cosine rule was invoked:

$$D = \sqrt{[D_A^2 + D_B^2 - 2D_A D_B \cos(\rho/3{,}600)]} \quad (1)$$

Where D is the mean separation distance of the two stars in pc; D_A is the mean distance from the Sun to the primary in pc, obtained from parallax measures; D_B is the mean distance from the Sun to the secondary in pc, and ρ is apparent separation in arcseconds (″) reported in this paper, Table 3.

The minimum and maximum distance separation was calculated using the data in Table 1, measure of apparent separation reported in this paper and Equation (1), Table 3.

The angle between each of the components space velocity vectors in 3-dimensions was calculated using the method of Nugent (Nugent, 2025), Table 3. Angles < 15° are designated as Common Space Motion pairs, values > 15° and < 30° are designated as Similar Space Motion pairs and values > 30° are designated as Different Space Motion pairs.

The space velocity of the A component and space velocity of the B component were calculated using the method of Nugent (Nugent, 2025). The relative 3-dimensional space velocity and system escape velocity were calculated using the method of Bonifacio (Bonifacio et al, 2020), Table 3.

Binding energy *($E_{binding}$)* was calculated using the following formula (Letchford et al, 2022).

$$E_{binding} = \frac{1}{2}\left(\frac{m_A m_B}{m_A + m_B}\right) v^2 - \frac{G m_A m_B}{D} \quad (3)$$

Where, $E_{binding}$ is in $M_\odot(\text{km s}^{-1})^2$; m_A and m_B are the masses of the primary and secondary in solar masses ($M_\odot$); v is the galactic space speed difference between the two stars in km s^{-1}; D is their physical separation in parsec (pc); and G is the gravitational constant (4.30091×10^{-3} pc$(\text{km s}^{-1})^2/M_\odot$).

3. Data

The results of the analysis of the 30 images by AstroImageJ are given in Table 2.

Table 2: Theta, rho & delta magnitude determined for LDS 63 using AstroImageJ.

WDS 01589-5652 LDS 63				
Epoch	**Measurement (n = 30 images)**	**Position Angle (degrees)**	**Separation (arcseconds)**	**Delta Magnitude (Bessel-V)**
2025.889 (JD: 2460993.595)	Mean	128.5	36.06	0.82
	Standard Deviation	0.04	0.053	0.02
	Standard Error of the Mean	0.01	0.010	0.003
Last measurement (2016.0)		128.5	36.04	0.78

Table 3. Space velocity of the primary, Space velocity of the secondary, angle between the space velocity vectors (Nugent metric), relative space velocity, system escape velocity, mean physical distance separation, minimum distance separation, maximum distance separation and overlap in distance for LDS 63.

WDS Identifier	Space velocity of Primary (km/s)	Space velocity of Secondary (km/s)	Angle between the space velocity vectors (degrees)	Relative space velocity (km/s)	System escape velocity using mean distance (km/s)	Mean Separation (AU)	Minimum Separation (AU)	Maximum Separation (AU)	Overlap in distance (AU)
01589-5652 LDS 63	117.6	117.9	0.10	0.3	0.5	16,506	4,753	115,707	84,904

The E_{binding} value was calculated to be +0.10 $M_\odot(\text{km s}^{-1})^2$ using the mean physical distance separation. Using the minimum separation distance, the E_{binding} value becomes –0.15 $M_\odot(\text{km s}^{-1})^2$.

4. Discussion

The study of double stars like LDS 64 raises an important question. What are the minimum astrophysical parameters necessary to identify a wide visual pair (which I will define as having an apparent separation of ≥ 5 arc seconds) as a binary star system?

Currently there is no consensus agreement as to what constitutes a binary star system based on distance separation (Jiménez-Esteban et. al. 2019). One view (based on a review of the literature) is that the approximate upper bound for physical 3D separation of a binary system is 2,500AU (Nugent, 2026). Other views suggest separation distances of up to ~20,000AU (Tokovinin A, personal communication) and ~50,000AU (Matson R, personal communication) for largest separation distances of bound binaries. An example of a binary pair with a mean distance separation of >2,500AU is 17191-4638 BSO 13 AB that has a mean separation distance of 7,452AU and evidence of orbital motion (Jaworski, 2026). Bound pairs with separation distances >20,000AU do exist (Mamajek, 2012), but it is increasingly difficult to separate them from young co-moving objects (Tokovinin A, personal communication). Wide systems are thought to be more likely found in the Galactic halo, where the probability of encountering stars is minimal, and in young associations, where the systems have had less time for encounters. The existence of wide binary systems (separations >20,000 AU) is particularly challenging to binary formation models as their physical separations are beyond the typical size of a collapsing cloud core (∼5000–10,000AU), (Jiménez-Esteban et. al. 2019). Some wide binaries are thought to be triple systems. Although the triple systems are born very compact and therefore initially are more protected against disruption by passing stars, they can develop extreme hierarchical architectures on timescales of millions of years as one component is dynamically scattered into a very distant orbit (Reipurth& Mikkola 2012). This explanation may apply to Proxima Centauri. Proxima Centauri and α Centauri A & B are gravitationally bound with a separation distance of 13,000 AU (currently close to apastron), (Kervella et. al. 2017).

Projected separation is highly important, but by itself is not sufficient and other criteria (e.g. common space motion, binding energy, relative 3D space velocity, system escape velocity) also need to be considered in the analysis. However, these other parameters should also not be taken in isolation. For example, the binding energy of a binary system should be negative. However, WDS 01398-5612 DUN 5 (p Eri) which shows clear evidence of orbital motion has a binding energy of +0.77 $M_{\odot}$(km s^{-1})^2 using GAIA DR3 data. It is the opinion of the author that all the parameters need to be considered in the final analysis.

Unequivocal evidence for a system being a binary is to demonstrate an observed orbit, which can be seen in binaries with Grade 1 orbits in the Sixth Catalog of Orbits of Visual Binary Stars (Matson et.al. 2026) because of their relatively short orbital period – days, years to decades. These pairs are composed of pairs that are very close (apparent separations of < 1 or 2 arc seconds) and usually observed with techniques like speckle interferometry. However, demonstration of an orbit is not often possible with wide visual pairs having projected long orbital periods (thousands of years+) and only limited observational data. At present often we can only suggest that a wide visual pair is a possible or probable binary based on consideration of all the available data.

LDS 63 has a mean separation distance of ~16,506AU. The minimum separation distance is ~4,753AU and the maximum separation distance is ~115,707AU. The overlap distance using 1σ parallax error is ~84,904 AU. The stars have masses of 1.53 $M_{\odot}$ and 1.24 $M_{\odot}$. The mean separation distance between the components of LDS 63 does not totally exclude them being a binary star system. The angle between each of the components space velocity vectors in 3D space of LDS 63 is 0.1 degrees which indicates the pair show common space motion. Binary stars ideally should have a negative binding energy. LDS 63 has an E_{binding} of +0.10 $M_{\odot}$(km s^{-1})^2 using the mean separation distance. However, using the minimum separation distance, the E_{binding} value becomes –0.15 $M_{\odot}$(km s^{-1})^2. Also, for LDS 63 the relative 3D space velocity is less than the system escape velocity which suggests a bound system.

5. Conclusion

An updated astrometric measurement of LDS 63 is provided. Analysis using GAIA DR3 data shows that the primary and secondary of LDS 63 are at least a co-moving pair and may possibly form a binary star system.

Acknowledgements

I would like to thank Dr. Rachel Matson for providing the historical data and assistance required for the analysis of WDS 01589-5652 LDS 63. I would also like to acknowledge the Boyce Research Initiatives and Education Foundation (https://boyce-astro.org/). Finally, I would like to thank Pat Boyce for providing the educational material and technical support required to complete this paper. I would like to thank Professor A. Tokovinin for his assistance.

This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory http://www.astro.gsu.edu/wds/.

This work has also 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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