An Astrometric Measurement of WDS 03370-2808 LDS 840 and Analysis using GAIA DR3 Data. Features consistent with a Binary Star System.

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Abstract

The components of WDS 03370-2808 LDS 840 show common proper motion and are included in the Luyten Double Star Catalogue. The nature of LDS 840 was further investigated using a current astrometric measure and GAIA DR3 data. LDS 840 was imaged using the Las Cumbres Observatory (LCO) Global Network of Telescopes. Calibrated images were obtained and analysed using the software AstroImageJ to determine separation, position angle and delta magnitude. Using GAIA DR3 data and apparent separation reported in this paper, minimum, mean and maximum physical distance separation was estimated. In addition, the angle between each of the components space velocity vectors in 3-dimensional space (Nugent metric), binding energy (E_{binding}), system escape velocity and relative 3-dimensional space velocity were calculated. Analysis shows that WDS 03370-2808 LDS 840 exhibits features consistent with a binary star system.

1. Introduction

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

LDS 840 AB was first measured in 1909.96 when the position angle was 222.9° and the separation was 30.865″ (Urban et al 1998). The last measure was in 2016.0 when the position angle was 224.47° and the separation was 31.34037″ (El-Badry et al, 2021).

Selected GAIA DR3 data for LDS 840 is shown in Table 1 (Prusti et. al. 2016; Vallenari et. al. 2023). The Renormalised Unit Weight Error (RUWE) for the primary is 0.958 and 1.062 for the secondary indicating a good single star fit.

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

Table 1: Selected data on LDS 840 from GAIA DR3. Stellar luminosity and mass values come for GAIA DR3 FLAME.

WDS Identifier 03370-2808 LDS 840	Parallax ± 1σ mas	Total proper motion mas/yr	pmra ± 1σ mas/yr	pmdec ± 1σ mas/yr	Radial velocity ± 1σ km/sec	Luminosity SolLum	Mass $M_\odot$
A Component Gaia source id: 5057255138421148928	17.4292 ± 0.0133	252.684	-75.37 ± 0.01	-241.18 ± 0.01	-25.18 ± 0.13	0.882	0.93
B Component Gaia source id: 5057254760464741888	17.4308 ± 0.0138	257.189	-74.72 ± 0.01	-246.10 ± 0.01	-24.86 ± 0.16	0.195	N/A

The distance from the Sun to the A and B components of LDS 840 with 1σ parallax uncertainties are shown in Fig. 1. The distances from the Sun to the primary and secondary show overlap.

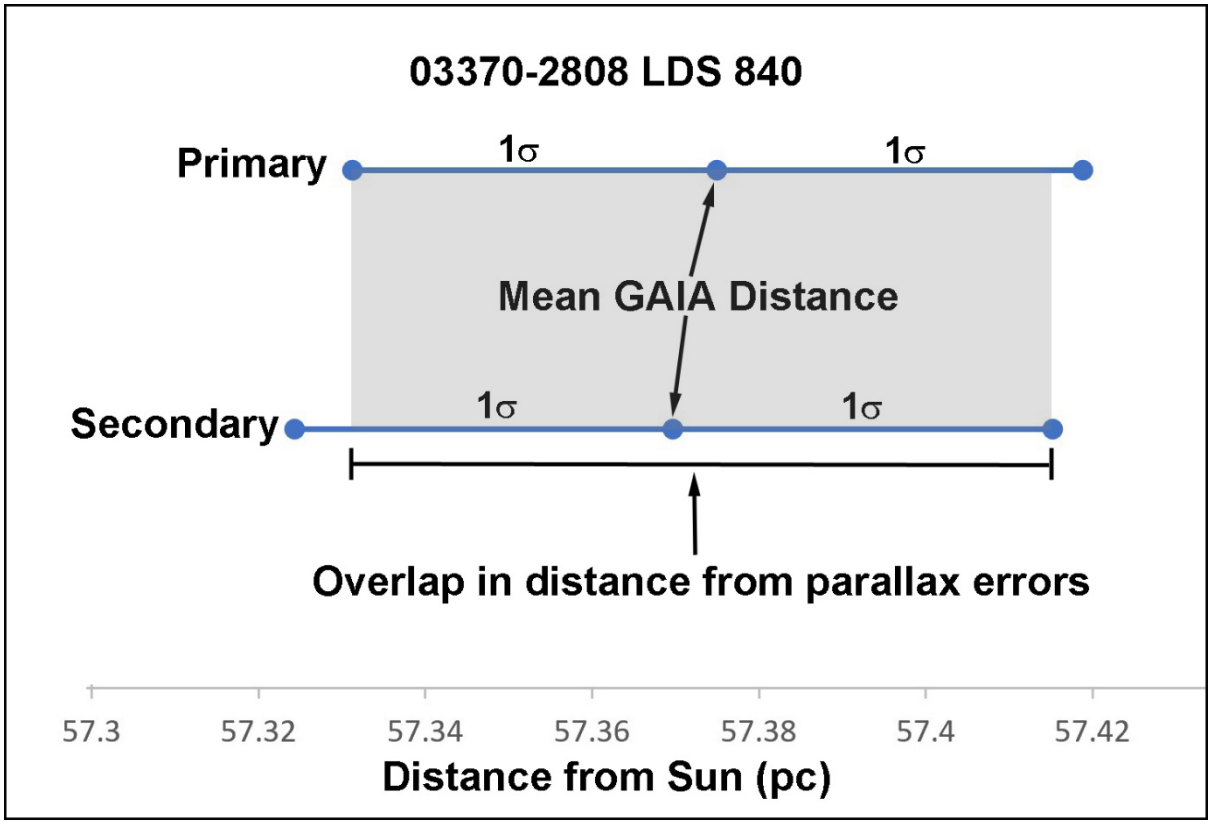

Figure 1: GAIA DR3 distances of the components of LDS 840 from the Sun including 1σ parallax errors

2. Methods

Using the Las Cumbres Observatory Global Network of Telescopes, LDS 840 AB was imaged on November 20, 2025 and December 13, 2025 (Mean Decimal Date: 2025.918; Mean JD UTC: 2461007.341) 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 central30x30. 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 November 20, 2025 and ten images were taken on December 13, 2025. The images were recorded through a Bessel-V Filter and the exposure time for each image was 30 seconds. The air mass for each set of images was 1.0 and 1.1 respectively. The calibrated images were individually inspected for quality and all were subsequently chosen for analysis. The two image sets were combined and all the images were analysed using AstroImageJ with apertures set at 8 pixels (object aperture), 12 pixels (inner radius of background annulus) and 16 pixels (outer radius of background annulus), Fig. 2. and mean value, standard deviation and standard error of the mean determined for theta, rho and delta magnitude, Table 2.

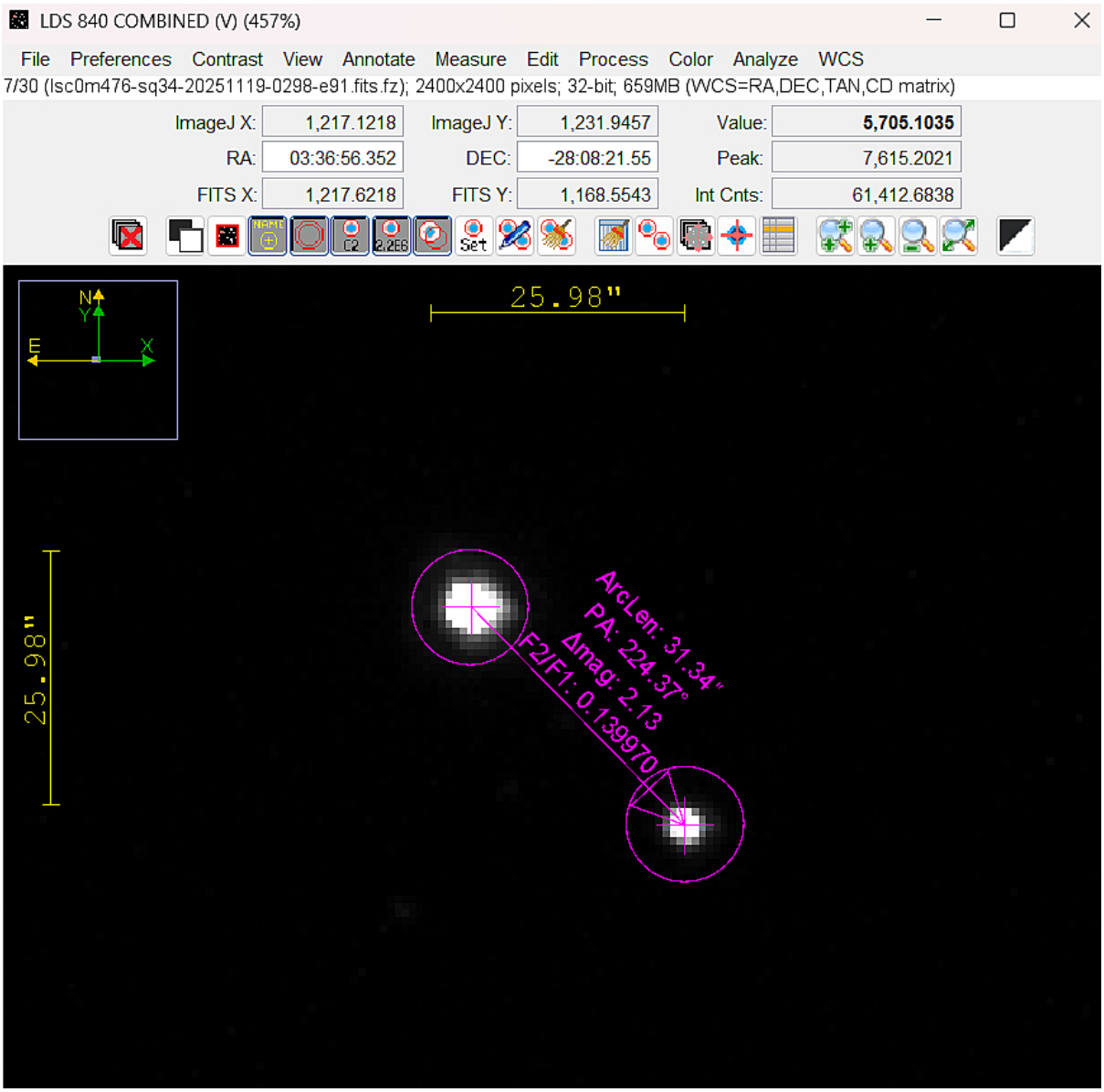

Figure 2: A representative image of LDS 840 analysed using AstroImageJ showing separation, position angle and delta magnitude

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

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

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 with 1σ uncertainty 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 (Nugent metric) 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).

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

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$(\text{km s}^{-1})^2/M_\odot$). The mass of the B component was not available with GAIA DR3 FLAME. Using the GAIA DR3 luminosity and Duric equations (Duric 2004, Letchford et al 2022)), the mass of the B component was estimated as 0.66 $M_\odot$.

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 03370-2808 LDS 840 using AstroImageJ.

WDS 03370-2808 LDS 840				
Epoch (Mean)	**Measurement**	**Theta (degrees)**	**Rho (arcseconds)**	**Delta Magnitude (Bessel-V filter)**
DD: 2025.918 JD: 2461007.341	Mean	224.4	31.36	2.13
	Standard Deviation	0.04	0.028	0.01
	Standard Error of the Mean	0.01	0.005	0.002
Last measurement (2016.0)		224.5	31.34	1.97

The mean physical distance separation of the A and B components of LDS 840 is 0.01 ± 0.06 pc which equates to ~2,063 AU.

The binding energy of LDS 840 using the mean physical distance separation is +0.01 $M_\odot(\text{km s}^{-1})^2$.

Table 3. Primary space velocity, secondary space velocity, relative angle between the space velocity vectors (Nugent metric), relative space velocity, system escape velocity, mean physical distance separation, minimum distance separation and maximum distance separation for 03370-2808 LDS 840.

WDS Identifier	Primary space velocity (km/s)	Secondary space velocity (km/s)	Angle between the space velocity vectors (degrees)	Relative space velocity (km/s)	System escape velocity (km/s)	Mean Separation (AU)	Minimum Separation (AU)	Maximum Separation (AU)
03370 -2808 LDS 840	73.2	74.2	0.7	1.4	1.2	2063	1799	19568

4. Discussion

Luyten's observations indicate that the components of WDS 03370-2808 LDS 840 show common proper motion. The angle between each of the components space velocity vectors in 3-dimensional space is 0.7 degrees indicating the pair also show common space motion. The mean physical distance separation is 2,063 AU, the minimum separation distance is 1,799 AU and the maximum separation distance is 19,568 AU. The approximate upper bound for physical 3D separation of a binary systems is 2,500 AU (Nugent, 2026). The system escape velocity and the relative space velocity are approximately comparable. Overall, LDS 840 show features consistent with a binary star system. If the orbit is assumed to be circular and the semi-major axis is ~1,032 AU and given the masses of the stars are 0.93 $M_{\odot}$ and 0.66 $M_{\odot}$ then the orbital period (using Kepler's third law) is ~26,292 years.

5. Conclusion

An updated astrometric measurement of WDS 03370-2808 LDS 840 is provided. Analysis using GAIA DR3 data shows that the components of WDS 03370-2808 LDS 840 show features consistent with a gravitational association.

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