An Astrometric Measurement of 04450-7026 LDS130 and Analysis using GAIA DR3 Data. Evidence Supporting a Binary Star System

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Abstract

The components of WDS 04450-7026 LDS130 show common proper motion and are included in the Luyten Double Star Catalogue. The nature of 04450-7026 LDS130 was further investigated using a current astrometric measure and GAIA DR3 data. WDS 04450-7026 LDS130 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, mean, minimum and maximum physical distance separation was estimated. In addition, the angle (v) between each of the components space velocity vectors in 3-dimensional space, Buchheim distance probability estimation, binding energy ($E_{binding}$), system escape velocity and relative 3-dimensional space velocity were calculated. Analysis shows that the components of WDS 04450-7026 LDS130 exhibit common space motion and show evidence supporting a binary star system.

1. Introduction

The Luyten Double Star Catalogue (LDS) is a list of double stars culled from William Jacob Luyten's Palomar Survey publications. The Luyten Double Star Catalogue may be accessed at https://vizier.cds.unistra.fr/viz-bin/VizieR?-source=I/130

04450-7026 LDS130 was first measured in 1913 when the position angle was 140° and the separation was 25″ (Melbourne Observatory cited in Southern Double Star Catalogue; Innes, 1927). The last measure was in 2016.0 when the position angle was 145.0° and the separation was 91.34″ (El-Badry et al, 2021). Both the primary and secondary are spectral class M (https://simbad.cds.unistra.fr/simbad/).

Selected GAIA DR3 data for 04450-7026 LDS130 is shown in Table 1 (Prusti et. al. 2016; Vallenari et. al. 2023). From the GAIA DR3 archive, the primary component of WDS 04450-7026 LDS130 has an RUWE of 1.037 and the secondary has an RUWE of 0.997. Both these values are consistent with a single-star model (Castro-Ginard et al, 2024).

Table 1. Selected data on 04450-7026 LDS130 from GAIA DR3.

WDS Identifier 04450-7026 LDS130	Parallax ± 1σ mAS	Total proper motion mAS/yr	pmra ± 1σ mAS/yr	pmdec ± 1σ mAS/yr	Radial velocity ± 1σ km/sec	Apparent Gaia G-band magnitude
A Component Gaia source id: 4654963689477989120	24.3014 ± 0.0111	200.973 ± 0.015	-102.465 ± 0.016	172.891 ± 0.014	8.2 ± 0.3	11.95
B Component Gaia source id: 4654963247075835520	24.3067 ± 0.0102	198.734 ± 0.013	-101.601 ± 0.014	170.799 ± 0.012	8.4 ± 0.3	12.07

2. Methods

Using the Las Cumbres Observatory Global Telescope Network, 04450-7026 LDS130 was imaged on November 23, 2025 and December 13, 2025 (Mean Decimal Date: 2025.922; Mean JD UTC: 2461009.300) at Cerro Tololo Inter-American Observatory with a PlaneWave DeltaRho 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 23, 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 40 seconds. The air mass for each set of images was <1.4. 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 6 pixels (object aperture), 10 pixels (inner radius of background annulus) and 14 pixels (outer radius of background annulus), Figure 1, and mean value, standard deviation and standard error of the mean determined for theta, rho and delta magnitude, Table 2.

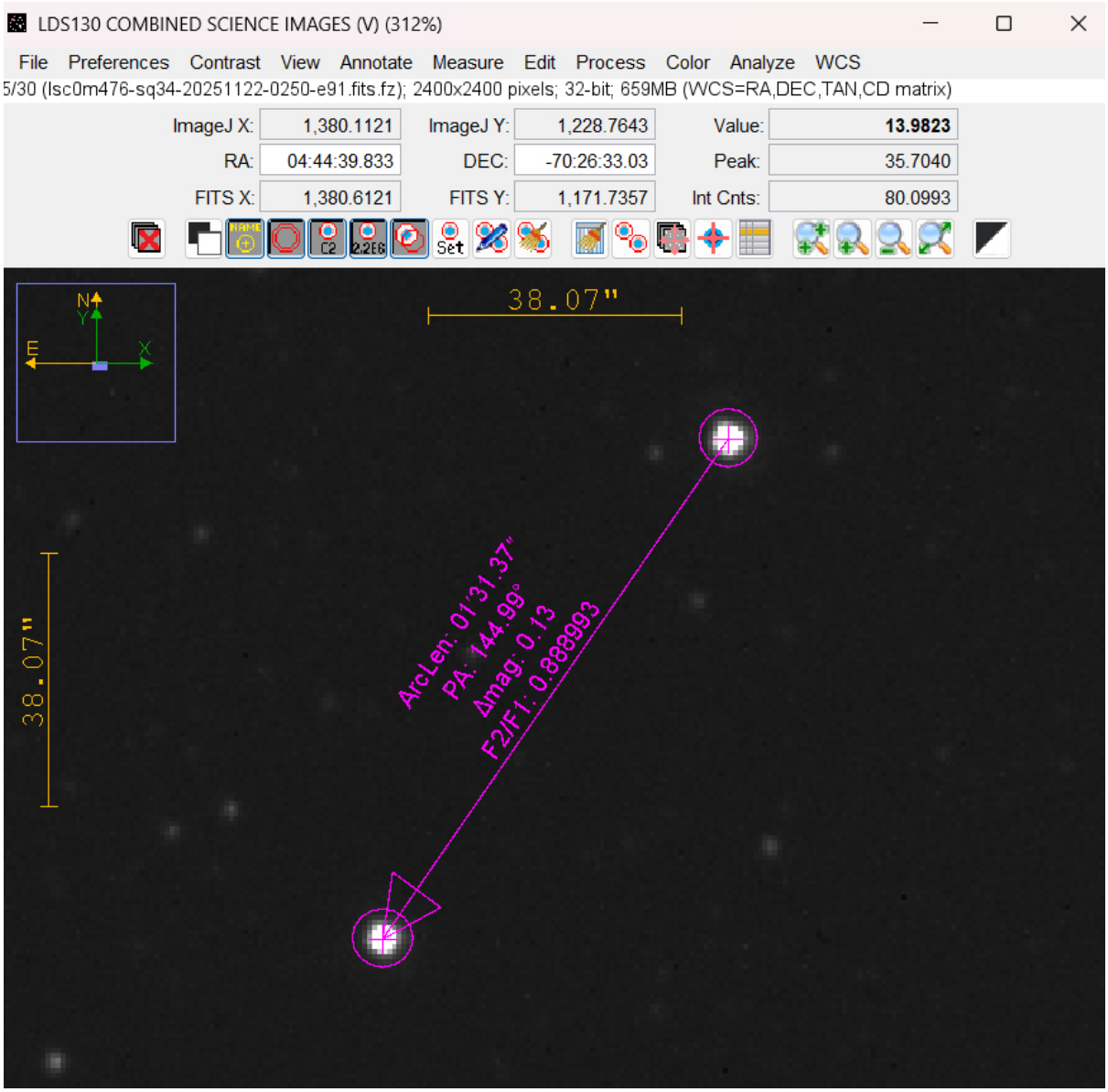

Figure 1: A representative image of 04450-7026 LDS130 analysed using AstroImageJ showing separation, position angle and delta magnitude.

To calculate *D*, the mean physical separation distance of the components in pc, the cosine rule was 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 measure; 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 separation distance (separation distance if the components are equidistant from the Sun) and maximum distance separation Fig. 2, 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 Buchheim's distance probability calculation involves calculating the probability that two stars are within one light-year of each other, using parallax and parallax error data from GAIA DR3. The core of the calculation uses the standard error of the mean of the probability distribution function of the distance difference between the two stars. Using this method (Sethi et al, 2024), the probability that the components of 04450-7026 LDS130 are within one light year of each other in the radial direction was calculated, Table 3.

Luminosity and stellar mass values for the primary and secondary of 04450-7026 LDS130 were not available from GAIA DR3 FLAME. Also, the GAIA DR2 luminosity for the primary and secondary was not available.

The mass of the primary and secondary were calculated using the distance (derived from mean GAIA DR3 parallax) and the apparent magnitude (Nugent, 2025).

Firstly, the absolute magnitude (M) was calculated using the following formula

$$M = m + 5 - 5\log_{10}(D) \quad (2)$$

Where m is the apparent Gaia G-band magnitude of the star and D is the distance between the star and the Sun (1/parallax), measured in parsecs.

Then the bolometric magnitude (Mbol) was calculated by adding the bolometric correction (BC) to the absolute magnitude (M) using the formula

$$Mbol = M + BC \quad (3)$$

The Teff (stellar effective temperature) of the primary and secondary from GAIA DR2 are 4,060K and 4,124K respectively. Bolometric corrections can be found here:
https://github.com/emamajek/SpectralType/blob/master/EEM_dwarf_UBVIJHK_colors_Teff.txt

With Mbol and the following mass-luminosity relationship, the mass of the primary and secondary was calculated

$$Mass = 10^{(0.48-0.105Mbol)} \quad (4)$$

The mass of the primary was estimated to be $0.44M_{\odot}$ and the mass of the secondary was estimated to be $0.43M_{\odot}$.

Binding energy ($E_{binding}$), Table 4, was calculated using the following formula (Letchford et al, 2022).

$$E_{binding} = \frac{1}{2}\left(\frac{m_A m_B}{m_A + m_B}\right) v^2 - \frac{G m_A m_B}{D} \quad (5)$$

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 system escape velocity and relative 3-dimensional space velocity were calculated using the method of Bonifacio (Bonifacio et al, 2020), Table 4. The distances from the Sun to the primary and secondary with 1σ parallax uncertainties overlap, Figure 2. The system escape velocity was calculated using the mean physical distance separation (D) as well as the minimum distance separation.

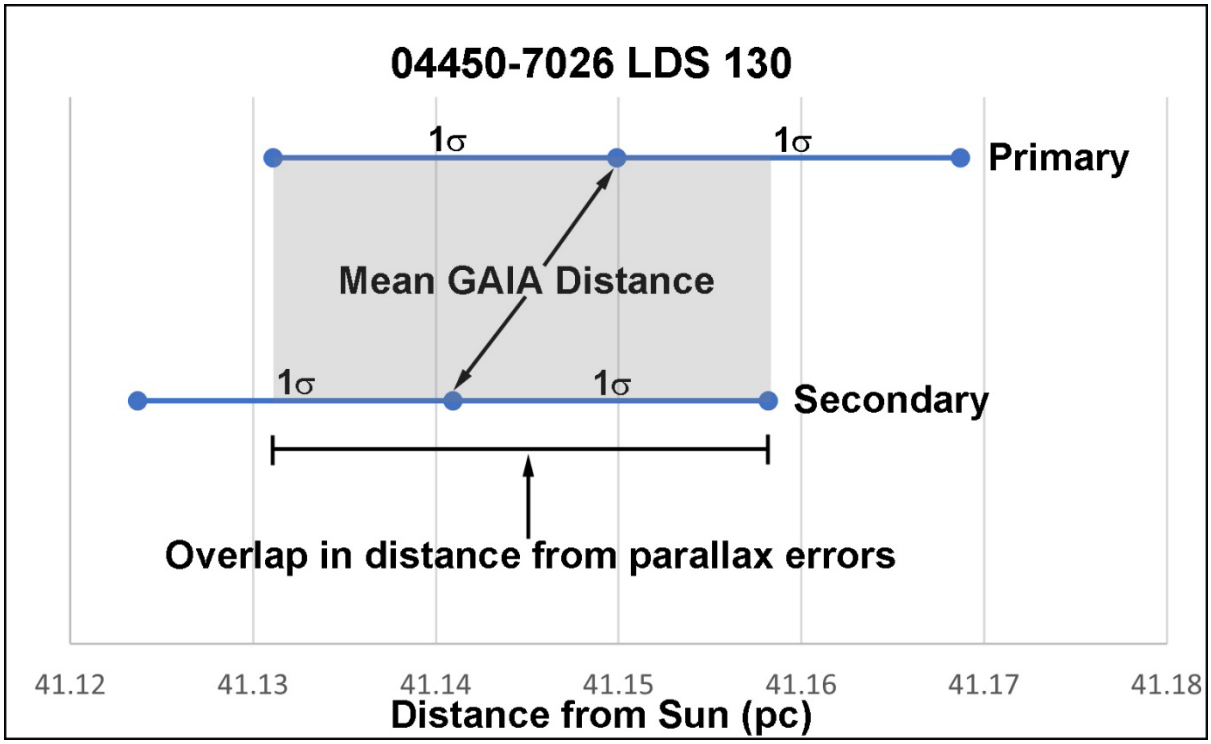

Figure 2: GAIA DR3 distances of the primary and secondary of 04450-7026 LDS130 from the Sun including 1σ parallax errors.

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 04450-7026 LDS130 using AstroImageJ.

WDS 04450-7026 LDS130				
Epoch (Mean)	**Measurement**	**Theta (degrees)**	**Rho (arcseconds)**	**Delta Magnitude (Bessel-V filter)**
2025.922 (JD: 2461009.300)	Mean	145.0	91.41	0.14
	Standard Deviation	0.01	0.034	0.01

Last measurements (2016.0)	Standard Error of the Mean	0.003 145.0	0.006 91.34	0.001 0.15

Table 3. Mean physical distance separation (*D*), minimum distance separation, maximum distance separation, angle (ν) between each of the components space velocity vectors in 3-dimensional space and Buchheim distance probability for 04450-7026 LDS130.

WDS IDENTIFIER	**Mean physical distance separation (*D*)** **AU**	**Minimum distance separation** **AU**	**Maximum distance separation** **AU**	**Angle (ν) between each of the components space velocity vectors in 3-dimensional space degrees**	**Buchheim distance probability calculation** **%**
04450-7026 LDS130	4,192	3,762	10,022	0.45	100

Table 4. Binding energy ($E_{binding}$), system escape velocity and relative 3D space velocity values for 04450-7026 LDS130.

WDS Identifier	**Binding energy ($E_{binding}$)** **$M_\odot(km\ s^{-1})^2$**	**System escape velocity using mean physical distance separation (*D*) km/s**	**System escape velocity using minimum distance separation km/s**	**Relative 3-dimensional space velocity** **km/s**
04450-7026 LDS130	+0.33	0.5	0.5	0.5

4. Discussion

The mean physical distance separation of the primary and secondary of WDS 04450-7026 LDS130 is 4,192AU (0.0203pc) with a minimum distance of 3,762AU and maximum distance of 10,022AU. The approximate upper bound for physical 3D separation of a binary system has been estimated to be ~2,500 AU (Nugent, 2026). However, another view is that wide gravitationally bound binaries may have separation distances of up to ~20,000 AU (Tokovinin A, personal communication). Luyten's observations indicate the components of WDS 04450-7026 LDS130 show common proper motion. Moreover, the angle (ν) between each of the components space velocity vectors in 3-dimensional space is 0.45 degrees indicating the pair show common space motion. The system escape velocity calculated using either the GAIA DR3 mean physical distance separation or the minimum distance separation is the same as the relative 3D space velocity. WDS 04450-7026 LDS130 has an $E_{binding}$ value of $+0.33 M_\odot(km\ s^{-1})^2$.

Letchford et al, 2022 proposed conservative criteria for binary double stars of (a) $E_{binding}$ <+1. Ideally $E_{binding}$ should be <0 however, in their 2022 paper Letchford et. al., included in their list of probable binaries pairs which had $E_{binding}$ (binding energy) <+1 (thus allowing for some uncertainties in $E_{binding}$) and observables consistent with a binary system, (b) a physical separation (*D*) such that $D - 1\sigma < 1$ pc, and (c) pairs which displayed common proper motion. WDS 04450-7026 LDS130 satisfies these criteria.

5. Conclusion

An updated astrometric measurement of WDS 04450-7026 LDS130 is provided. Analysis using GAIA DR3 data shows that the components of WDS 04450-7026 LDS130 exhibit common space motion and show evidence supporting a binary star system.

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