An Astrometric Measurement of WDS 04198-6622 LDS118 AB and Analysis using GAIA DR3 Data

Richard C. Jaworski

Macquarie University, Sydney, NSW. Australia; richjaw001@gmail.com

Abstract

The components of WDS 04198-6622 LDS118 AB show common proper motion and are included in the Luyten Double Star Catalogue. The nature of LDS118 AB was further investigated using a current astrometric measure and GAIA DR3 data. LDS118 AB 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 04198-6622 LDS118 AB is an optical double in which the components are co-moving. Based on parallax measurements WDS 04198-6622 BAU15 AC is an optical double.

1. Introduction

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

LDS118 AB was first measured in 1920 when the position angle was 135° and the separation was 32″ (Luyten, 1941: CPM pairs found by comparison of Bruce proper motion plates. First and second plates epochs were 1898-1904 and 1928-1936, so a default mean date of 1920 was assigned to all measures). The last measure was in 2016.0 when the position angle was 152.14° and the separation was 31.61898″ (El-Badry et al, 2021).

Selected GAIA DR3 data for LDS118 AB is shown in Table 1 (Prusti et. al. 2016; Vallenari et. al. 2023). The Renormalised Unit Weight Error (RUWE) for the primary is 0.927 and 1.228 for the secondary.

[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 LDS118 AB from GAIA DR3. Stellar luminosity and mass values come for GAIA DR3 FLAME.

WDS Identifier 04198-6622 LDS118 AB	Parallax ± 1σ mas	Total proper motion ± 1σ 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: 4668780156861957632	5.7402 ± 0.0123	132.607 ± 0.017	107.274 ± 0.017	77.955 ± 0.017	61.09 ± 0.34	0.92	0.92
B Component Gaia source id: 4668780156861958016	5.7443 ± 0.0125	132.159 ± 0.016	106.559 ± 0.016	78.173 ± 0.017	60.79 ± 0.67	0.25	0.75

The A component of LDS118 AB is also the A component of WDS 04198-6622 BAU 15 AC. The last measure of the separation of BAU15 AC was 40.222″ in 2016 (WDS Catalog historical notes: Knapp, 2025 private communication). The GAIA DR3 parallax of the C component is 0.8382 ± 0.0206 mas.

The distances from the Sun to the A and B components of LDS118 AB with 1σ parallax uncertainties are shown in Fig. 1. The distances from the Sun to the primary and secondary show overlap.

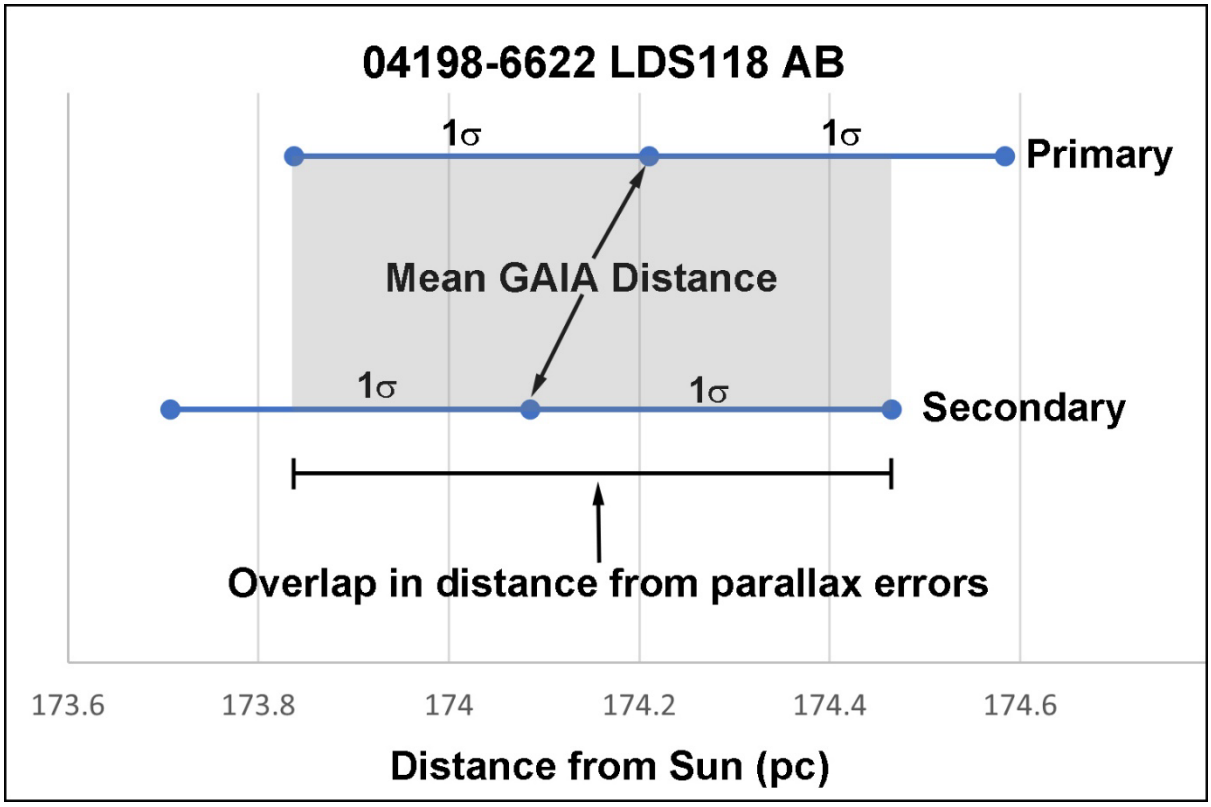

Figure 1: GAIA DR3 distances of the components of LDS118 AB from the Sun including 1σ parallax errors

2. Methods

Using the Las Cumbres Observatory Global Network of Telescopes, LDS118 AB was imaged on November 22, 2025 and December 13, 2025 (Mean Decimal Date: 2025.921; Mean JD UTC: 2461008.604) 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 22, 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 1.3 and 1.4 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 6 pixels (object aperture), 10 pixels (inner radius of background annulus) and 14 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.

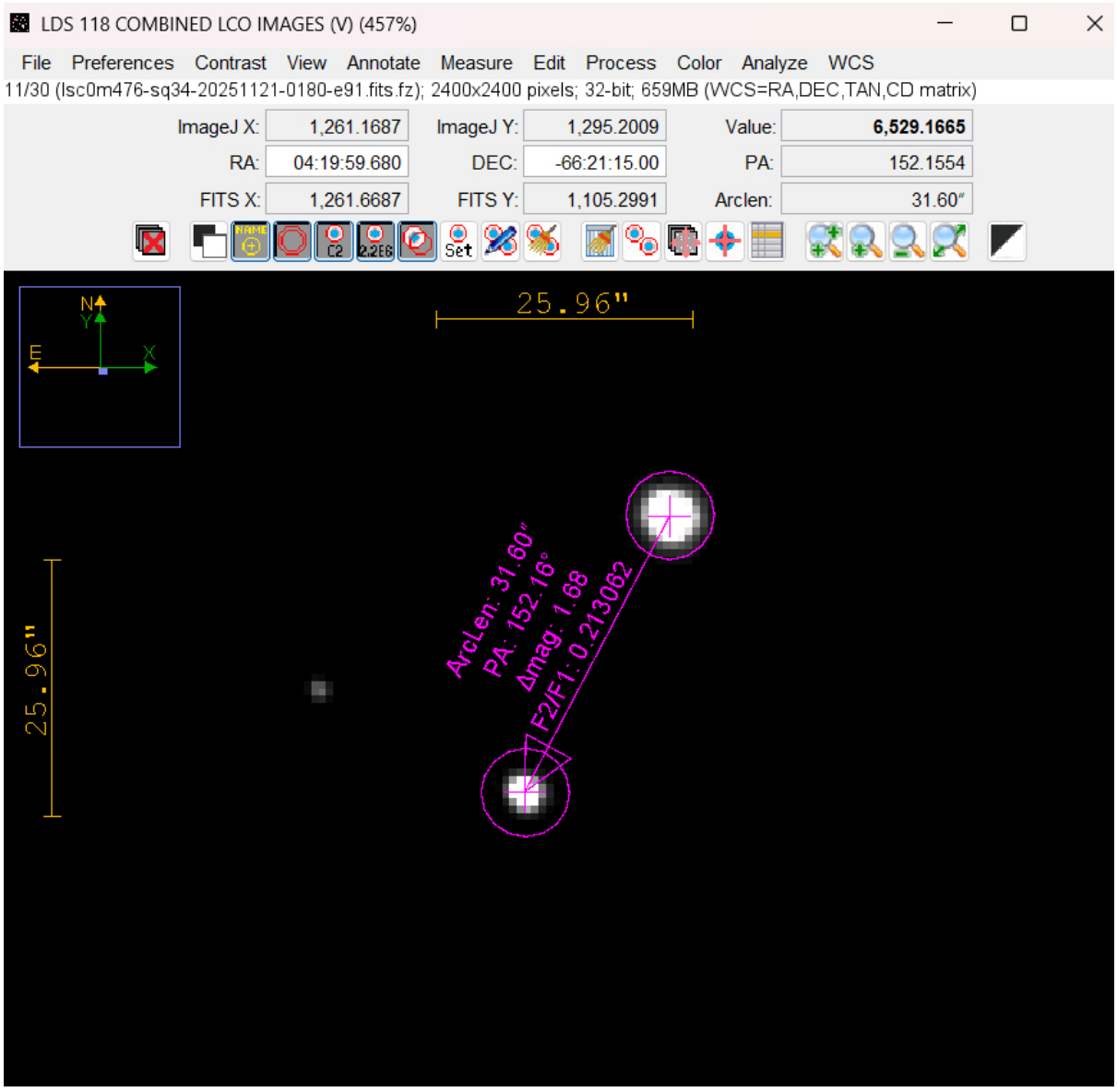

Figure 2: A representative image of LDS118 AB analysed using AstroImageJ showing separation, position angle and delta magnitude

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 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$(\text{km s}^{-1})^2/M_\odot$).

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 04198-6622 LDS118 AB using AstroImageJ.

WDS 04198-6622 LDS118 AB				
Epoch (Mean)	**Measurement**	**Theta (degrees)**	**Rho (arcseconds)**	**Delta Magnitude (Bessel-V filter)**
DD: 2025.921 JD: 2461008.604	Mean	152.1	31.60	1.68
	Standard Deviation	0.04	0.02	0.01
	Standard Error of the Mean	0.01	0.003	0.001
Last measurement (2016.0)		152.1	31.62	1.5

The mean physical distance separation of the A and B components of LDS118 is 0.127 (± 0.532) pc which equates to ~26,196AU.

The binding energy of LDS118 AB using the mean physical distance separation is +0.65 $M_{\odot}$(km s^{-1})^2.

Table 3. Primary space velocity (SV), 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 04198-6622 LDS118 AB.

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 Sep (AU)	Min Sep (AU)	Max Sep (AU)
04198-6622 LDS118 AB	125.4	124.9	0.23	0.731	0.335	26,196	5,505	180,062

4. Discussion

Luyten's observations indicate the components of WDS 04198-6622 LDS118 AB show common proper motion. The angle between each of the components space velocity vectors in 3-dimensional space is 0.23 degrees indicating the pair show common space motion. The mean physical distance separation is ~26,196 AU, the minimum separation distance is ~5,505 AU and the maximum separation distance is ~180,062AU. The approximate upper bound for physical 3D separation of a binary systems is 2,500AU (Nugent, 2026). Also, the system escape velocity is less than the relative 3D space velocity calculated using the mean physical distance separation based on the GAIA mean distances. Thus, it is likely that the A and B components are an optical pair in which the components are co-moving.

The mean physical distance separation of the components of 04198-6622 BAU15 AC is 1018.82 ± 29.32 pc indicating the components form an optical double.

5. Conclusion

An updated astrometric measurement of WDS 04198-6622 LDS118 AB is provided. Analysis using GAIA DR3 data shows that the components of WDS 04198-6622 LDS118 AB are unlikely to be gravitationally associated but form a co-moving pair.

WDS 04198-6622 BAU15 AC is an optical double star.

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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 (DAC, https://www.cosmos.esa.int/web/gaia/Dac/consortium).
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