Astrometric Measurement of WDS 09595-5001 HJ4274 with Analysis using GAIA DR3 Data

Richard C. Jaworski

Macquarie University, Sydney, New South Wales, Australia; richjaw001@gmail.com

Abstract

WDS 09595-5001 HJ4274 is a double star located in the Constellation of Vela. The nature of HJ4274 was investigated using an updated astrometric measure and GAIA DR3 data. HJ4274 was imaged using the Las Cumbres Observatory Global Telescope Network. Calibrated images were obtained and analysed using the software AstroImageJ to determine separation, position angle 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, space velocities of the primary and secondary, angle between each of the components space velocity vectors in 3D space, system escape velocity, relative 3D space velocity and $E_{binding}$, were calculated. The analysis indicates that HJ4274 is an optical double in which the components show common space motion.

1. Introduction

09595-5001 HJ4274 was first measured at epoch 1834.28 when the position angle was 350° and the separation was 15″ (Herschel, 1847). The last measure was in 2015.0 when the position angle was 349.2° and the separation was 18.61″ (Knapp and Nanson, 2018). The Vmagnitude of the A component is 9.79 and the Vmagnitude of the B component is 10.76. The A component is a spectroscopic binary of spectral types A1/2IV/V+A0/2 (SIMBAD https://simbad.cds.unistra.fr/simbad/).

Selected GAIA DR3 data on HJ4274 is shown in Table 1 (Prusti et. al. 2016; Vallenari et. al. 2023). The Renormalised Unit Weight Error (RUWE) for the primary is 1.368 and 0.976 for the secondary. The value of 1.368 for the A component is consistent with it being a spectroscopic binary. The RUWE value of the secondary indicates a good single star model.

Table 1. Selected GAIA DR3 data on HJ4274. Luminosity and stellar mass values come from GAIA DR3 FLAME.

WDS Identifier 09595-5001 HJ4274	**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: 5405435595823218560)	2.5895 ± 0.0198	18.117 ± 0.022	-17.606 ± 0.022	4.275 ± 0.020	11.79 ± 1.74	16.6 1.9
B Component (Gaia source id: 5405435595823220480)	2.5845 ± 0.0124	16.339 ± 0.014	-15.861 ± 0.014	3.927 ± 0.012	14.24 ± 1.17	7.4 1.6

The distance from the Sun to the primary and secondary of HJ4274 with 1σ parallax uncertainties are shown in Figure 1. The distances from the Sun to the primary and secondary show overlap.

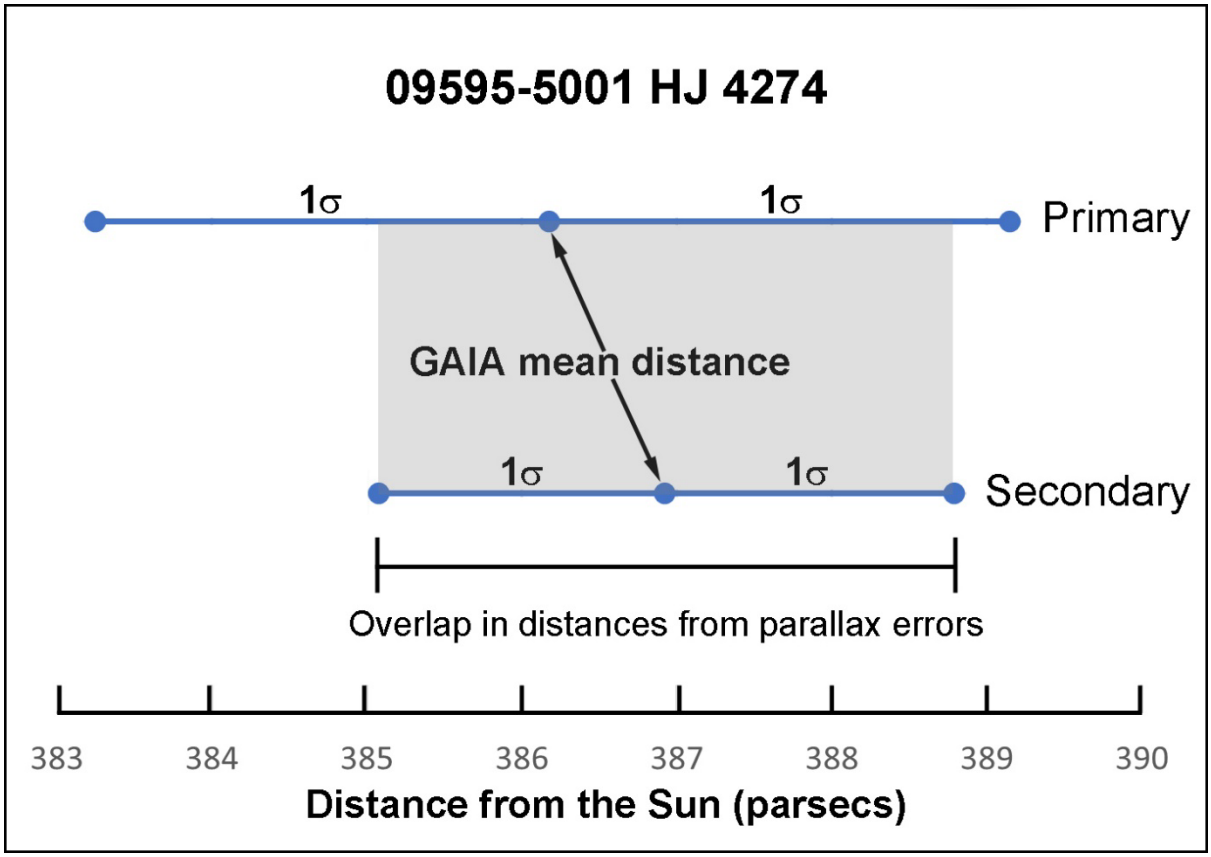

Figure 1: GAIA DR3 distances of the components of 09595-5001 HJ4274 from the Sun including 1σ parallax errors

2. Methods

Using the Las Cumbres Observatory Global Telescope Network, 09595-5001 HJ4274 was imaged on May 3, 2025 (Decimal Date: 2025.336; JD: 2460799.493) at Cerro Tololo Inter-American Observatory. Images were taken with a Planewave Delta Rho 350 telescope and QHY600 CMOS camera systems. The camera format was 9576 x 6388 pixels, 3.76 micron pixels size, FOV 1.9 x 1.2 degrees readout mode full frame, 30'x30' in readout mode central 30x30, pixel size ~0.74″/pixel, default binning 1 x 1, read noise ~ 3 to 3.5 e- and gain 0.7 e-/ADU.

Twenty images were recorded through a Bessel-V Filter and the exposure time for each image was 4 seconds. The air mass was 1.1. 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 5 pixels (object aperture), 8 pixels (inner radius of background annulus) and 12 pixels (outer radius of background annulus) and mean value, standard deviation and standard error of the mean determined for position angle, separation and delta magnitude, Table 2.

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 was calculated using the data in Table 1, the 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 primary and space velocity of the secondary was 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.

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

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

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 mean 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 20 images by AstroImageJ is given in Table 2.

Table 2. Position angle, separation & delta magnitude determined for 09595-5001 HJ4274 using AstroImageJ.

Epoch	Measurement (n = 20 images)	Position Angle (degrees)	Separation (arcseconds)	Delta Magnitude (Bessel-V filter)
DD: 2025.336 (JD: 2460799.493)	Mean	349.2	18.62	0.90
	SD	0.03	0.021	0.01
	SEM	0.01	0.005	0.002
Last measurement (2015.0)		349.2	18.61	0.97

Table 3. Primary space velocity, secondary space velocity, 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 HJ4274.

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 using mean distance separation (km/s)	Mean Separation (AU)	Minimum Separation (AU)	Maximum Separation (AU)	Overlap in distance (AU)
09595-5001 HJ4274	35.2	33.2	5.9	4.0	0.2	154,268	7,191	1,143,312	765,242

The mean distance separation of the primary and secondary of HJ4272 is 0.748 pc. The $E_{binding}$ (binding energy) is +6.76 $M_{\odot}(km\ s^{-1})^2$.

4. Discussion

The primary and secondary of HJ4274 have a mean separation distance of ~154,268 AU. The approximate upper bound for physical 3D separation of most binary systems is 2,500 AU (Nugent, 2026). For wide gravitationally bound binaries an upper border of 50,000AU has been suggested (Matson R, personal communication). HJ4274 has an $E_{binding}$ of +6.76 $M_{\odot}(km\ s^{-1})^2$ and the relative 3D space velocity is greater than the system escape velocity (20 times). These findings indicate that HJ4274 is an optical double. The angle between each of the components space velocity vectors in 3D space is 5.9 degrees which indicates the pair show common space motion.

5. Conclusion

An updated astrometric measure of 09595-5001 HJ4274 is reported. The above analysis indicates that HJ4274 is an optical double in which the components are co-moving.

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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).
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