Astrometric Measurements of LDS 119, LDS 180, LDS 292, LDS 398, LDS 850, LDS 986, LDS 987, LDS 1099, LDS 2532 and LDS 5189 with Analysis using GAIA Data

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Abstract

The components of LDS 119, LDS 180, LDS 292, LDS 398, LDS 850, LDS 986, LDS 987, LDS 1099, LDS 2532 and LDS 5189 show common proper motion and are included in the Luyten Double Star Catalogue. The 10 double stars were further investigated using a current astrometric measure and GAIA data. The 10 double stars were 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 (v) between each of the components space velocity vectors in 3-dimensional space (Nugent metric), binding energy ($E_{binding}$), relative 3-dimensional space velocity and system escape velocity were calculated.

1. Introduction

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

The 10 double stars were selected for study as the parallax of the components was similar and the pairs could be studied using the methodology used in this paper.

Selected GAIA DR3 data for the 10 double stars is shown in Table 1 (Prusti et. al. 2016; Vallenari et. al. 2023).

[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 119, LDS 180, LDS 292, LDS 398, LDS 850, LDS 986, LDS 987, LDS 1099, LDS 2532 and LDS 5189 from GAIA DR3, unless otherwise specified. Stellar luminosity and mass values come for GAIA DR3 FLAME.

WDS Identifier	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⊙	RUWE
04254-5211 LDS 119	7.9840	263.557	167.447	-203.528	85.08	N/A	1.596
A Component	±		±	±	±		
Gaia source id:	0.0169		0.019	0.024	0.97	N/A	
4781023938821713024							
B Component	7.9850	259.817	168.469	-197.796	82.58	0.14	1.263
Gaia source id:	±		±	±	±		
4781023732662278656	0.0128		0.014	0.017	1.92	0.71	
07250-3821 LDS 180	20.4568	122.472	-2.821	-122.440	-17.43	0.39	1.006
A Component	±		±	±	±		
Gaia source id:	0.0110		0.013	0.013	0.16	0.80	
5586022443570622208							
B Component	20.4443	121.446	-0.6750	-121.445	-17.38	0.34	0.899
Gaia source id:	±		±	±	±		
5586022409211089792	0.0099		0.012	0.012	0.17	0.78	
09582-2943 LDS 292	19.5236	143.314	69.901	-125.111	37.34	0.17	1.055
A Component	±		±	±	±		
Gaia source id:	0.0158		0.016	0.016	0.24	0.69	
5463835842379952768							
B Component	19.5559	142.197	67.743	-125.024	36.47*	N/A	3.218
Gaia source id:	±		±	±	±		
5463835846675463424	0.0466		0.052	0.050	3.79	N/A	
12165-5736 LDS 398	19.8694	104.022	-101.711	21.807	0.89	0.18	0.830
A Component	±		±	±	±		
Gaia source id:	0.0118		0.010	0.011	0.24	0.74	
6071772902486934528							
B Component	19.5103	114.044	-111.623	23.378	-0.06	N/A	4.293
Gaia source id:	±		±	±	±		
6071772902486933376	0.0493		0.045	0.052	0.26	N/A	
07025-1443 LDS 850	23.0044	324.103	117.889	-301.902	-27.81	0.169*	1.200
A Component	±		±	±	±		
Gaia source id:	0.0165		0.012	0.013	0.14	N/A	
2948291780795832192							
B Component	23.0408	324.642	121.925	-300.876	-27.37	0.065*	1.851
Gaia source id:	±		±	±	±		
2948291780795831168	0.0271		0.022	0.022	0.20	N/A	
16569+2541 LDS 986	16.2764	216.251	129.816	-172.952	-49.80	0.24	0.984
A Component	±		±	±	±		
Gaia source id:	0.0119		0.011	0.013	0.18	0.78	
1306220642729543936							
B Component	16.2877	216.804	127.065	-175.666	-48.99	0.22	1.083
Gaia source id:	±		±	±	±		
1306220264772422016	0.0140		0.013	0.017	0.19	0.78	
17045+0345 LDS 987	13.6709	269.870	-218.358	-158.586	-109.68	0.23	1.078
A Component	±		±	±	±		
Gaia source id:	0.0158		0.017	0.012	0.22	0.75	
4391440645244877824							
B Component	13.6789	274.785	-218.951	-166.034	-108.54	0.17753303	16.730
Gaia source id:	±		±	±	±		
4391252972356658816	0.2543		0.292	0.208	0.62	N/A	

01292+2900 LDS 1099	4.7993	61.691	-27.383	-55.280	-28.29	1.41	0.985
A Component	±		±	±	±		
Gaia source id:	0.0167		0.018	0.015	0.41	1.06	
297119828878741376							
B Component	4.8008	61.711	-27.348	-55.321	-29.51	0.81	1.109
Gaia source id:	±		±	±	±		
297119828878682112	0.0194		0.022	0.016	0.39	0.91	
07241+6722 LDS 2532	20.8627	176.618	38.553	-172.359	35.21	N/A	1.074
A Component	±		±	±	±		
Gaia source id:	0.0143		0.008	0.011	0.14	N/A	
1107985598251523200							
B Component	20.8765	173.160	38.415	-168.845	34.62	N/A	1.289
Gaia source id:	±		±	±	±		
1107985602551964672	0.0231		0.012	0.018	0.24	N/A	
04289+4222 LDS 5189	10.4903	181.951	79.945	-163.447	79.27	N/A	1.109
A Component	±		±	±	±		
Gaia source id:	0.0184		0.019	0.016	0.34	N/A	
228258377706727808							
B Component	10.4825	181.873	79.030	-163.805	78.02	0.18	1.170
Gaia source id:	±		±	±	±		
228258442129361152	0.0177		0.018	0.016	0.45	0.70	

* GAIA DR2 Data

2. Methods

Using the Las Cumbres Observatory Global Network of Telescopes, the 10 double stars were imaged 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.

The image acquisition details are shown in Table 2. The images from both sets for each pair were combined and analysed using AstroImageJ, Figure 1, to determine position angle, separation and delta magnitude, Table 3.

Table 2. Image acquisition details for LDS 119, LDS 180, LDS 292, LDS 398, LDS 850, LDS 986, LDS 987, LDS 1099, LDS 2532 and LDS 5189.

WDS Identifier	Decimal Date	Number of images	Exposure sec	Air mass	Filter
04254-5211 LDS 119	2025.8945	15	40	1.2	Bessel-V
	2025.9493	10	40	1.1	
	Mean 2025.922				
07250-3821 LDS 180	2025.9411	20	8	1.3	Bessel-V
	2025.9493	10	8	1.3	
	Mean 2025.945				
09582-2943 LDS 292	2026.0753	10	38	1.1	Bessel-V
	2026.0781	10	38	1.1	
	Mean 2026.077				
12165-5736 LDS 398	2026.3192	15	8	1.2	Bessel-V
	2026.5247	10	8	1.5	
	Mean 2026.422				
07025-1443 LDS 850	2025.9301	20	20	1.5	Bessel-V
	2025.9493	10	20	1.2	
	Mean 2025.940				
16569+2541 LDS 986	2026.0781	10	12	1.6	Bessel-V
	2026.0808	10	12	1.5	
	Mean 2026.079				

17045+0345 LDS 987	2026.0781 2026.0808 Mean 2026.079	10 10	20 20	1.6 1.5	Bessel-V
01292+2900 LDS 1099	2025.8315 2025.9521 Mean 2025.892	20 30	30 10	1.0 1.0	Bessel-V
07241+6722 LDS 2532	2026.0726 2026.0753 Mean 2026.074	10 10	20 20	1.3 1.3	Bessel-V
04289+4222 LDS 5189	2025.9 2025.9466 Mean 2025.923	19 10	40 40	1.0 1.1	Bessel-V

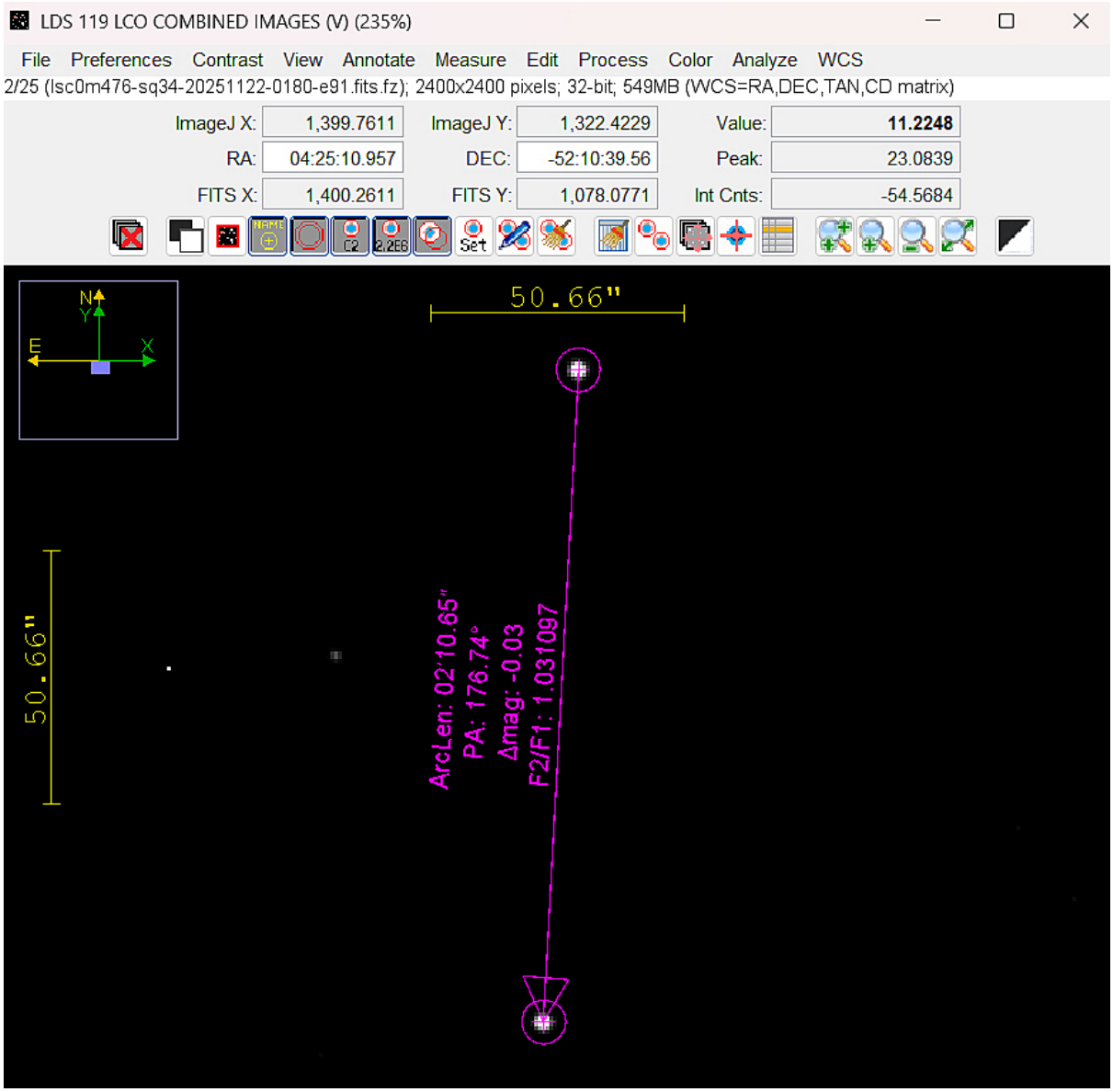

Figure 1: A representative image of LDS 119 analysed using AstroImageJ showing separation, position angle and delta magnitude.

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 4.

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 4.

The angle (v) between each of the components space velocity vectors in 3-dimensions (Nugent metric) was calculated using the method of Nugent (Nugent, 2025a), Table 4. 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 were calculated using the method of Nugent (Nugent, 2025a). The relative 3-dimensional space velocity and system escape velocity were calculated using the method of Bonifacio (Bonifacio et. al., 2020), Table 4.

The luminosity and mass of the primary of LDS 119 was not available from GAIA DR3 FLAME. Using the GAIA DR2 luminosity value of 0.119 SolLum, the mass of the primary was determined to be 0.59 $M_\odot$ using the following relationship between individual luminosity (L in solar units) and individual mass (M in solar masses), Equation (2), (Duric, 2004; Letchford et. al., 2022). Similarly for LDS292 the GAIA DR2 luminosity of the secondary is 0.168 SolLum and the mass is calculated as 0.64 $M_\odot$. For LDS 398 the GAIA DR2 luminosity of the secondary is 0.136 SolLum and the mass is calculated as 0.61 $M_\odot$. For LDS 850 the GAIA DR2 luminosity of the primary is 0.169 SolLum and 0.065 SolLum for the secondary which translates to an estimated mass of 0.64 $M_\odot$ and 0.50 $M_\odot$ for the primary and secondary respectively. For LDS 987 the GAIA DR3 luminosity of the secondary is 0.18 SolLum and its mass is estimated to be 0.65 $M_\odot$. For LDS 5189 the GAIA DR2 luminosity of the primary is 0.167 SolLum which translates to an estimated mass of 0.64 $M_\odot$.

$$M = \begin{cases} (L/0.23)^{1/2.3}, & \text{if } M < 0.43 \\ L^{1/4}, & \text{if } 0.43 < M < 2 \\ (L/1.4)^{1/3.5}, & \text{if } 2 < M < 55 \\ L/32{,}000, & \text{if } M > 55 \end{cases} \quad (2)$$

For LDS 2532 the GAIA DR2 luminosity of the primary is 0.197 SolLum and its mass is estimated to be 0.67 $M_\odot$. No luminosity value was available for the secondary. The mass of the secondary was calculated using the following method (Nugent, 2025b).

Firstly, the absolute magnitude (*Mabs*) is calculated using the formula

$$Mabs = Mapp + 5 - 5\log_{10}(D) \quad (3)$$

where *Mapp* is the apparent Gaia G-band magnitude of the star, magnitude +11.93 (https://simbad.cds.unistra.fr/simbad/), and D is the distance between the star and the Sun, measured in parsecs using the formula

$$D = 1/Plx \quad (4)$$

where *Plx* is the parallax of the star (arcsec), Table 1.

Using Equation (3) the absolute magnitude (*Mabs*) is calculated as 8.53. The bolometric magnitude (*Mbol*) is given by the formula

$$Mbol = Mabs + BC \quad (5)$$

Where BC is the bolometric correction. For the secondary which has a Teff of 4,244 K (GAIA DR2), the bolometric correction is approximately –0.75 (Pecaut & Mamajek, 2013)[2]. Thus

$$Mbol = 8.53 + (-0.75)$$
$$= 7.78$$

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

$$Mass = 10^{(0.48-0.105Mbol)} \quad (6)$$

The mass of the secondary was estimated to be ~0.46$_{\odot}$.

Binding energy ($E_{binding}$), Table 5, was calculated using the following formula (Letchford et al, 2022).

$$E_{binding} = \frac{1}{2}\left(\frac{m_A m_B}{m_A+m_B}\right)v^2 - \frac{G m_A m_B}{D} \quad (7)$$

Where, $E_{binding}$ is in $M_{\odot}(km\ s^{-1})^2$; 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$(km\ s^{-1})^2/M_{\odot}$).

3. Data

The results of the analysis of the 10 double stars using AstroImageJ are given in Table 3.

Table 3. Position angle, separation and delta magnitude determined for LDS 119, LDS 180, LDS 292, LDS 398, LDS 850, LDS 986, LDS 987, LDS 1099, LDS 2532 and LDS 5189 using AstroImageJ.

	Mean Epoch	Measurement	Theta (degrees)	Rho (arcseconds)	Delta Magnitude (Bessel-V filter)
04254-5211 LDS 119	DD: 2025.922 JD: 2461010.608	Mean	176.7	130.63	0.03
		Standard Deviation	0.01	0.036	0.01
		Standard Error of the Mean	0.002	0.007	0.001
	Last measurement (2015.5)		176.7	130.60	0.05
07250-3821 LDS 180	DD: 2025.945 JD: 2461020.653	Mean	76.1	34.41	0.21
		Standard Deviation	0.04	0.044	0.01
		Standard Error of the Mean	0.01	0.008	0.001
	Last measurement (2016.0)		76.2	34.47	0.23
09582-2943 LDS 292	DD: 2026.077 JD: 2461069.181	Mean	138.0	16.43	0.21
		Standard Deviation	0.08	0.023	0.003
		Standard Error of the Mean	0.02	0.005	0.001
	Last measurement (2022.16021)		138.4	16.31	0.3

[2] https://github.com/emamajek/SpectralType/blob/master/EEM_dwarf_UBVIJHK_colors_Teff.txt

12165-5736 LDS 398	DD: 2026.422 JD: 2460980.516	Mean	338.4	12.82	0.66
		Standard Deviation	0.12	0.027	0.01
		Standard Error of the Mean	0.02	0.005	0.002
	Last measurement (2015.5)		338.6	12.77	0.59
07025-1443 LDS 850	DD: 2025.940 JD: 2461018.113	Mean	123.4	28.71	1.63
		Standard Deviation	0.05	0.031	0.01
		Standard Error of the Mean	0.01	0.006	0.001
	Last measurement (2016.0)		123.4	28.69	1.6
16569+2541 LDS 986	DD: 2026.079 JD: 2461070.240	Mean	265.5	8.56	0.09
		Standard Deviation	0.10	0.032	0.01
		Standard Error of the Mean	0.02	0.007	0.002
	Last measurement (2018.493)		265.5	8.53	0.11
17045+0345 LDS 987	DD: 2026.079 JD: 2461070.276	Mean	176.0	40.13	0.87
		Standard Deviation	0.03	0.026	0.01
		Standard Error of the Mean	0.01	0.006	0.001
	Last measurement (2015.515)		175.7	40.11	0.74
01292+2900 LDS 1099	DD: 2025.892 JD: 2461006.330	Mean	254.7	17.80	0.60
		Standard Deviation	0.06	0.011	0.01
		Standard Error of the Mean	0.01	0.002	0.001
	Last measurement (2016.0)		254.7	17.80	0.66
07241+6722 LDS 2532	DD: 2026.074 JD: 2461068.034	Mean	316.7	40.36	2.33
		Standard Deviation	0.03	0.021	0.01
		Standard Error of the Mean	0.01	0.005	0.002
	Last measurement (2016.0)		316.7	40.35	2.13
04289+4222 LDS 5189	DD: 2025.923 JD:	Mean	240.2	10.17	0.23 0.01
		Standard Deviation	0.13	0.015	0.001
		Standard Error of the Mean	0.02	0.003	
	Last measurement (2017.1999)		240.3	10.19	0.2

Table 4. Space velocity of primary, space velocity of secondary, relative angle (v) 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 distances with 1σ error for LDS 119, LDS 180, LDS 292, LDS 398, LDS 850, LDS 986, LDS 987, LDS 1099, LDS 2532 and LDS 5189.

WDS Identifier	Primary space velocity (km/s)	Secondary space velocity (km/s)	Angle (v) 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)	Overlap in distances with 1σ error (AU)

04254-5211 LDS 119	178.1	174.9	0.9	4.3	0.4	16,677	16,333	100,717	82,816
07250-3821 LDS 180	33.3	33.1	0.9	0.5	0.7	6,390	1,682	16,557	4,143
09582-2943 LDS 292	51.0	50.2	0.6	1.0	0.4	17,470	842	51,087	17,100
12165-5736 LDS 398	24.8	27.7	2.2	3.0	0.1	191,071	158,255	224,014	N/A*
07025-1443 LDS 850	72.3	72.2	0.7	1.0	0.4	14,220	1,248	31,143	2,803
16569+2541 LDS 986	80.3	79.9	0.9	1.4	0.6	8,808	526	28,945	11.361
17045+0345 LDS 987	144.2	144.4	1.1	2.8	0.5	9,299	2,935	301,509	34,875
01292+2900 LDS 1099	67.2	67.7	0.9	1.2	0.5	13,931	3,709	336,442	299,103
07241+6722 LDS 2532	53.4	52.4	0.2	1.0	0.5	6,816	1,935	24,314	11,181
04289+4222 LDS 5189	114.2	113.4	0.5	1.3	0.4	14,663	969	82,345	53,087

* No overlap in distances of primary and secondary of LDS 398 from the Sun with 1σ error

Table 5. Binding energy ($E_{binding}$) for LDS 119, LDS 180, LDS 292, LDS 398, LDS 850, LDS 986, LDS 987, LDS 1099, LDS 2532 and LDS 5189.

WDS Identifier	**Binding Energy ($E_{binding}$) $M_{\odot}(km\ s^{-1})^2$**
04254-5211 LDS 119	+7.2
07250-3821 LDS 180	–0.1
09582-2943 LDS 292	+0.2
12165-5736 LDS 398	+1.6
07025-1443 LDS 850	0.0
16569+2541 LDS 986	+0.3
17045+0345 LDS 987	+0.3
01292+2900 LDS 1099	+0.3

07241+6722 LDS 2532	+0.3
04289+4222 LDS 5189	+0.3

4. Discussion

Updated astrometric measurements of LDS 119, LDS 180, LDS 292, LDS 398, LDS 850, LDS 986, LDS 987, LDS 1099, LDS 2532 and LDS 5189 are provided.

Based on common space motion, negative $E_{binding}$ and relative 3D space velocity less than system escape velocity, 07250-3821 LDS 180 shows evidence of being a binary star system.

LDS 119 is an optical double ($E_{binding}$ $+7.2M_{\odot}(km\ s^{-1})^2$ and relative space velocity greater than the system escape velocity) with the components showing common space motion. LDS 398 has a mean physical distance separation of 191,071AU and $E_{binding}$ of $+1.6M_{\odot}(km\ s^{-1})^2$ indicating an optical double.

The other double stars are composed of co-moving pairs. All show $E_{binding}$ of <+1 and their mean physical distance separations are <20,000AU. The possibility that some of these pairs form binary star systems cannot be completely excluded.

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