

# *Journal of Double Star Observations*

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# A Possible New Double Star from Lunar Occultation: SAO 163677

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**Abstract:** A lunar occultation observation by the author in May 2012 detected a possible new double star: SAO 163677.

## SAO 163677

On 2012 May 11, a lunar occultation reappearance of SAO 163677 was video-recorded at 25 frames/sec using a 25cm telescope. The waning moon was 62% illuminated. The recorded light curve is shown in Figure 1 (next page).

The intermediate step lasted for 0.14 secs, with the fainter star reappearing from behind the moon first. The position angle of the event at the moon's limb was 220.5° and the radial velocity of the moon at the location of the occultation was 0.3681"/second. The consequent separation of the components of this star is at least 0.052". The magnitudes of SAO 163677 are M<sub>V</sub> 9.43 and M<sub>B</sub> 10.03. From the heights of the three portions of the light curve, the V magnitudes of the components are derived as 9.8 and 10.7.

The archive of Lunar Occultation Observations shows there were 2 earlier lunar occultations observations of this star in 1974 and 1996. Both were disappearances, at position angles 77.8° and 104.4° respectively. Neither observation revealed any double nature of the star, which is not surprising as a disappearance of the fainter star before the brighter star would not have been seen by a visual observer. A video observation of the May 2012 occultation by D. Gault in Australia was made at position angle 278.5° through a variable thin cloud. As a result of the cloud, the observation is inconclusive regarding the presence of a double star.

Star	SAO 163677 = TYC 5767-519-1 = HD 195733 = PPM 237591
Coord. (J2000)	20h 33m 29.30s, -13° 33' 12.1"
Spectral type	G0
Derived double data:	
Mag A	9.8 ± 0.1 (V)
Mag B	10.7 ± 0.1 (V)
Epoch	2012.36
Separation	> 0.052"
PA at epoch	between 130 and 310 deg

## References

- Lunar Occultation Archive: VizieR Catalogue number VI/132A
- D. Gault, private communication.

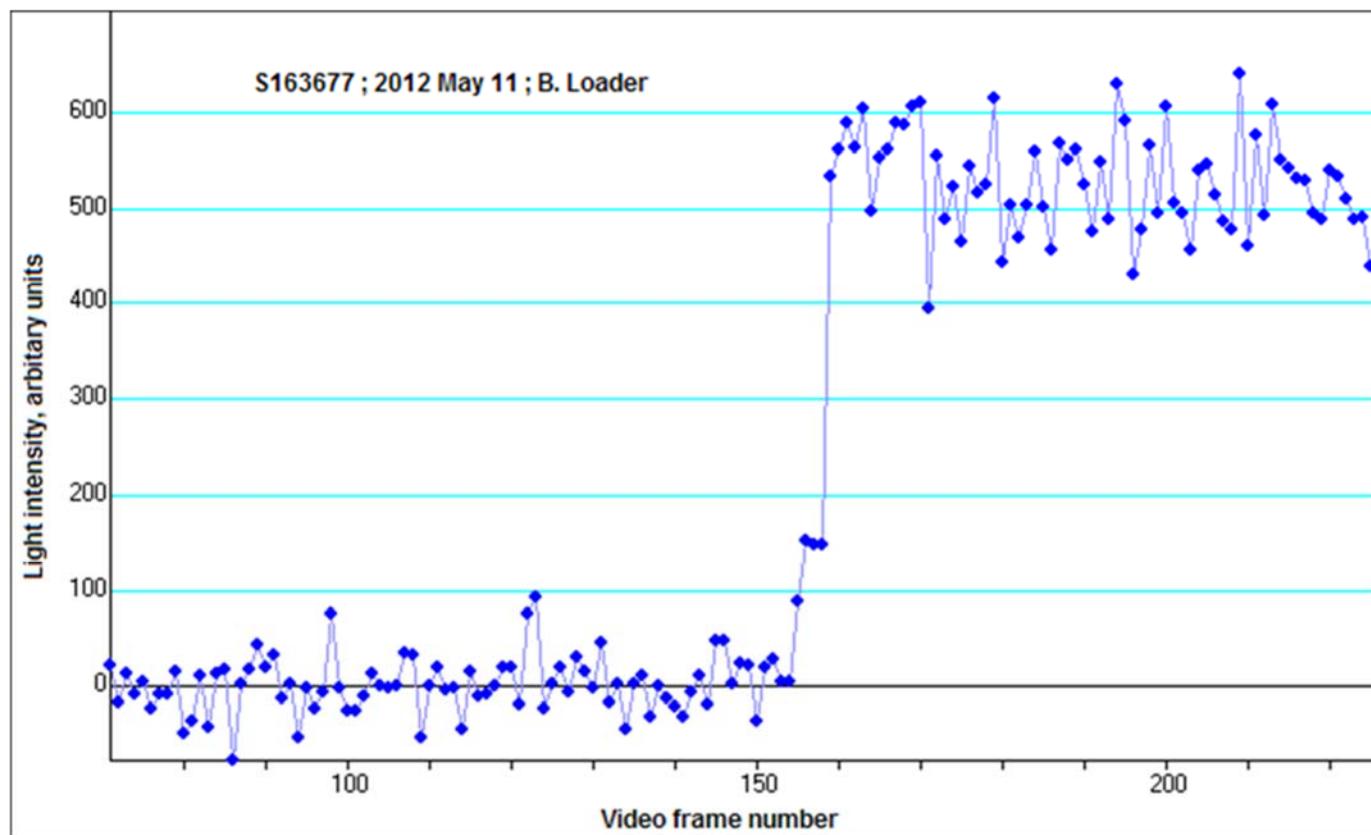
**A Possible New Double Star from Lunar Occultation: SAO 163677**

Figure 1. Light curve of lunar occultation.



# A New Double Star Observed During Lunar Occultation: HIP 18473

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**Abstract:** A lunar occultation observation by the author in March 2013 detected a new, previously unknown double star HIP 18473.

## HIP 18473

On 2013 March 17, a lunar occultation disappearance of HIP 18473 was video-recorded at 25 frames/sec using a 30cm telescope. The waxing moon was 28% illuminated. The recorded light curve is shown in Figure 1 on the next page.

The intermediate step lasted for 0.32 secs, with the fainter star being occulted first. The position angle of the event at the moon's limb was 44° and the radial velocity of the moon at the location of the occultation was 0.258"/second. The consequent separation of the components of this star is at least 0.083".

The magnitudes of HIP 18473 are M<sub>V</sub> 8.79 and M<sub>B</sub> 9.11. From the heights of the three portions of the light curve the V magnitudes of the components are derived as 9.5 and 9.6.

There are no previous observations of this star in the Archive of Lunar Occultation Observations that report double star effects.

There is no entry for this star in the hip\_dm\_g file.

Results for the observation are given below.

Star	HIP 18473 = HD 24761 = SAO
93681 = TYC 1257-345-1 = PPM 93096	
Coord. (J2000)	03h56m52.73s, 20° 05' 01.02"

Spectral type	A
Derived double data:	
Mag A	9.5 ±0.1 (V)
Mag B	9.6 ±0.1 (V)
Epoch	2013.21
Separation	>0.083"
PA at epoch	between 134 and 314 deg

## Reference

Lunar Occultation Archive: VizieR Catalogue number VI/132A

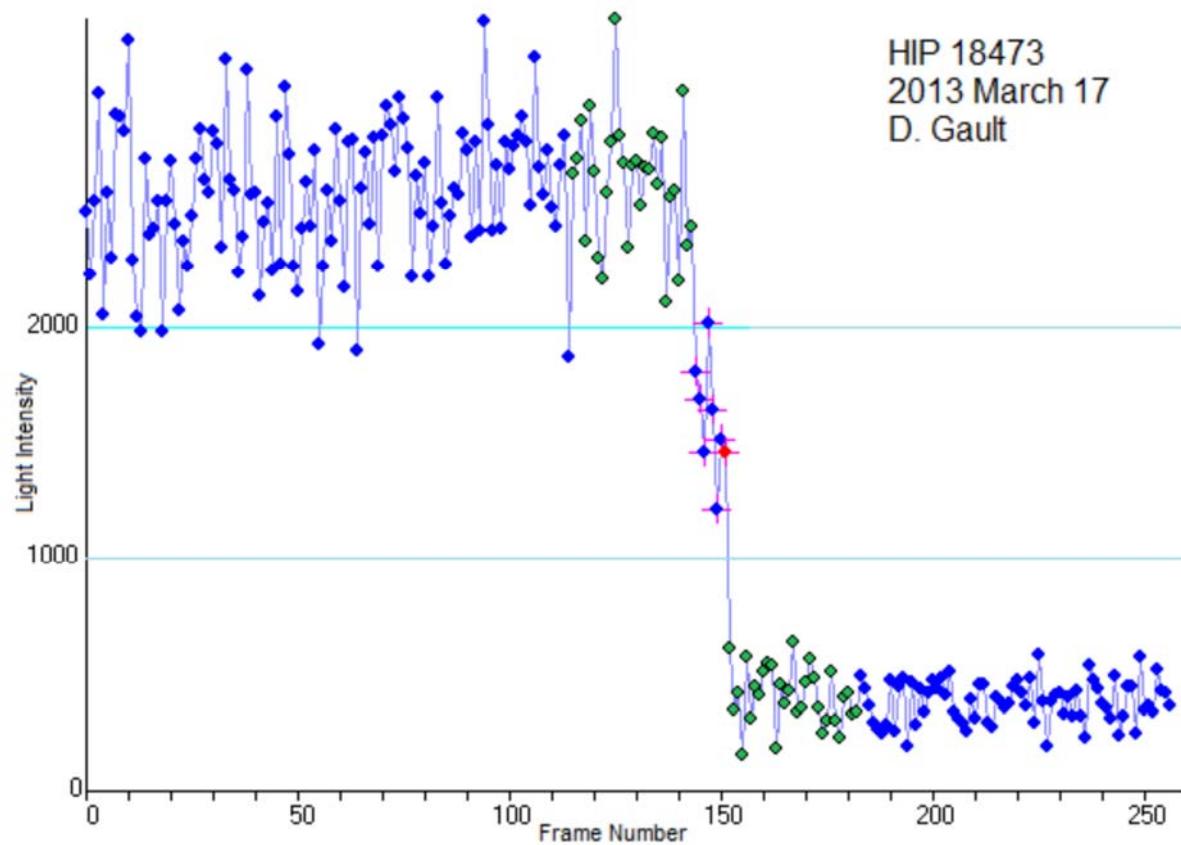
**A New Double Star Observed During Lunar Occultation: HIP 18473**

Figure 1. Light Curve of the Lunar Occultation.

# Double Star Measurements for 2010/2011

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**Abstract:** I report 88 measurements of double stars from 2010.90 to 2011.46. The observations were conducted with the T11 robotic telescope located at the GRAS/iTelescopes Observatory, Mayhill, NM, USA (<http://www.itelescope.net/>). Discussion includes notes on a number of the observed doubles. Information about instrumentation, methodology and results is included.

## Introduction and Instrumentation

I have been imaging double stars for a number of years using the equipment at GRAS/iTelescopes (hereafter iTelescopes). During this observing period the facility changed ownership.

The program of measuring the visual doubles used the T11 remote telescope at the GRAS Observatory. The instrument is a Planewave 20 in Dall-Kirkham Astrograph with a focal length of approximately 2280 mm. The CCD camera is a FLI ProLine PL11002M with 9  $\mu\text{m}$  square pixels. The field of view is 36.2 X 54.3 arc-secs. The OTA is mounted on a Planewave Ascension 200HR.

The instrument is capable of quickly and accurately slewing to a selected double star. The system takes about one minute to cycle through an exposure and save the resulting image in a FITS format. Taking 5 to 6 exposures per double star allows 6 doubles to be imaged per hour. To maximize telescope time, the FITS images are stored on the GRAS server and are retrieved later to analyzed by suitable software (in my case MPO Canopus). The relatively short focal length of this system restricts measurements of doubles to pairs  $> 10$  arcseconds in most cases.

## Methods

Imaging was done by entering the coordinates of the double into the robotic telescope's web interface. A test exposure was done and checked for centering and proper exposure. If all was well an exposure run of 5 to 7 images through a clear filter was done for each pair. Exposures typically ran about 10-15 seconds for 10-13 magnitude doubles. After the observing session was completed, the images were retrieved from an ftp site provided by the iTelescope observatory.

Each image in the exposure sequence was examined and any trailed or sub-par images were discarded. MPO Canopus was used to reduce the images (Warner 2006). Any image that the software could not reach a plate solution was also discarded. Canopus produces an astronomic solution to the image based on the UCAC2.0 catalog (Zacharias et al. 2004) or the MSOSC catalog (USNO and Tycho data) in areas not covered by UCAC2.0. The software measures double stars using a subroutine built into Canopus. It also produces a great amount of information about the astrometric solution. All images were copied to archival CD-ROM material and are available by request from the author. Each starting and ending image was blinked - just in case.

(Continued on page 10)

**Double Star Measurements for 2010/2011**

<b>WDS ID</b>	<b>Discoverer</b>	<b>RA</b>	<b>DEC</b>	<b>PA</b>	<b>SEP</b>	<b>Epoch</b>	<b>No.</b>	<b>PAsd</b>	<b>SEPsd</b>	<b>Notes</b>
04429+5532	STI2066	0443.80	5532.00	358.90	14.49	2010.902	6	0.21	0.02	1
05061+6232	STI 549	0507.10	6234.00	311.40	13.84	2010.841	5	0.25	0.04	
05064+2433	POU 541 ?	0506.90	2435.00	40.80	19.33	2011.145	5	0.22	0.16	2
05079+2425	POU 554	0508.60	2426.00	106.00	10.63	2011.131	5	0.6	0.11	
05081+2427	POU 556	0508.80	2428.00	58.70	2.31	2011.131	5	1.75	0.32	
05086+2507	POU 558	0509.30	2507.00	21.90	13.96	2011.131	6	0.22	0.08	
05087+2501	POU 559AB	0509.50	2502.00	336.60	19.07	2011.131	5	0.42	0.09	
05092+2428	POU 564	0509.90	2429.00	133.50	9.49	2011.074	5	0.57	0.36	
05111+5440	STI2087	0512.20	5440.00	112.10	9.25	2010.902	5	0.66	0.26	
05137+2418	POU 589	0514.40	2419.00	180.90	12.84	2011.074	5	1.46	0.39	
05138+2417	POU 592AC	0514.50	2418.00	324.30	9.05	2011.074	3	0.77	0.33	
05214+2343	POU 679	0522.10	2344.00	128.20	5.29	2011.074	6	1.1	0.67	
05225+4621	ES 1231AC	0523.30	4621.00	18.50	18.33	2010.842	5	0.1	0.02	
05230+5432	STI2096	0523.90	5433.00	32.50	10.55	2010.842	5	0.27	0.05	3
05238+5904	STI2097	0524.70	5905.00	183.50	6.40	2010.841	5	0.43	0.19	
05268+5623	STI2099	0527.70	5624.00	300.20	36.38	2010.902	4	0.14	0.05	
05315+2318	POU 698	0532.20	2318.00	122.90	10.86	2010.841	5	0.16	0.02	
05316+2312	POU 699	0532.20	2312.00	278.40	8.16	2010.841	5	1.62	0.32	
05314+2313	POU 696	0532.60	2313.00	98.00	14.87	2010.841	5	0.65	0.11	4
05321+2409	POU 709	0535.80	2410.00	243.20	10.48	2011.145	3	0.35	0.12	
05316+6310	STI 567	0533.00	6310.00	153.80	12.34	2010.841	5	0.23	0.05	5
05325+2404	POU 713	0533.10	2405.00	121.15	13.63	2011.131	4	0.3	0.08	
05328+6359	ES 1886	0533.90	6400.00	34.40	9.88	2010.902	5	0.86	0.22	
05337+2312	POU 721	0534.40	2312.00	322.10	6.49	2011.145	11	0.49	0.24	
05338+2315	POU 723	0534.50	2316.00	158.80	10.77	2011.145	10	0.52	0.15	
05336+2313	POU 719	0534.60	2314.00	20.50	9.67	2011.145	10	0.44	0.07	
05340+2309	POU 725	0534.60	2310.00	89.10	13.67	2011.145	11	0.34	0.19	
05342+2401	POU 728	0534.90	2401.00	46.00	15.47	2011.074	5	0.36	0.21	
05347+2346	POU 733	0535.30	2346.00	84.40	14.13	2011.074	5	0.43	0.04	
05347+2346	POU 736	0535.60	2443.00	157.05	12.43	2011.145	10	0.2	0.12	
05350+2445	POU 738	0535.70	2445.00	51.50	9.34	2011.145	4	0.4	0.09	
05358+2305	POU 741AB	0536.30	2305.00	296.00	20.60	2011.074	6	0.14	0.06	6
05358+2305	POU 742AC	0536.30	2305.00	329.80	17.91	2011.074	6	0.19	0.07	
05373+2453	POU 754	0538.00	2453.00	350.40	15.05	2011.131	5	0.41	0.05	7
05382+2429	POU 764	0538.90	2429.00	53.90	19.12	2011.131	5	0.38	0.28	
05446+6320	STI 579	0545.60	6321.00	123.90	7.58	2010.841	5	0.69	0.14	
05463+2423	POU 771	0547.00	2424.00	9.80	10.55	2011.131	5	0.32	0.05	
05469+4250	ES 1626	0548.70	4250.00	262.70	7.49	2010.902	5	0.66	0.25	
05492+2454	POU 786	0549.90	2455.00	353.50	17.02	2011.074	5	0.24	0.09	8
05511+2344	POU 794	0551.80	2344.00	266.60	9.35	2011.074	5	0.77	0.09	9

*Table continues on next page.*

**Double Star Measurements for 2010/2011**

<b>WDS ID</b>	<b>Discoverer</b>	<b>RA</b>	<b>DEC</b>	<b>PA</b>	<b>SEP</b>	<b>Epoch</b>	<b>No.</b>	<b>PAsd</b>	<b>SEPsd</b>	<b>Notes</b>
05518+5831	STI2111	0552.70	5831.00	122.70	13.54	2010.902	5	0.15	0.01	
05522+3901	ALI 812	0553.00	3901.00	36.90	9.21	2010.902	5	0.68	0.25	
05524+5450	STI2113	0553.30	5450.00	41.60	12.09	2010.902	5	0.49	0.05	
05527+2419	POU 800	0553.40	2419.00	322.40	8.32	2011.074	10	0.76	0.12	
05533+2419	POU 805	0554.00	2419.00	308.30	4.98	2011.074	15	1.22	0.38	10
05535+4434	ES 1379	0533.90	4436.00	339.00	8.95	2010.902	5	0.26	0.03	
05536+2423	POU 807	0554.30	2423.00	348.50	15.45	2011.074	5	0.11	0.08	
05538+2417	POU 808	0554.40	2417.00	44.90	13.82	2011.074	5	0.76	0.08	
05557+2308	POU 815	0556.30	2308.00	67.80	10.68	2011.131	5	0.22	0.11	
05558+2302	POU 818	0556.50	2303.00	129.10	7.35	2011.131	10	0.74	0.2	11
05566+1709	J 954	0557.20	1711.00	89.30	5.67	2010.902	5	1.13	0.23	
05587+2335	POU 833	0559.40	2335.00	162.90	11.51	2011.074	5	0.27	0.08	
05591+2437	POU 836	0559.80	2436.00	326.90	15.61	2011.074	5	0.56	0.07	
05597+2436	POU 839AB	0600.40	2437.00	230.70	10.94	2011.074	5	0.71	0.09	
06132+1334	J 1939AB	0613.90	1332.00	219.60	7.23	2010.842	5	0.3	0.02	
				219.61	7.13	2001.605				CMC14
				219.48	7.34	2000.325				UCAC2
				219.46	7.31	1999.710				UCAC4
				219.42	7.34	1997.800				2MASS
				219.37	7.35	1990.030				PPMXL
				222.04	6.88	1908.059				AC200.2
06132+1334	J 1929AC	0613.90	1332.00	34.60	13.88	2010.842	5	0.24	0.04	
				34.74	13.81	2001.062				CMC14
				34.77	13.77	2000.526				UCAC2
				34.76	13.77	2000.230				UCAC4
				34.71	13.81	1997.800				2MASS
				34.71	13.79	1990.030				PPMXL
				34.99	14.37	1908.059				AC200.2
	J 1929AD	0613.90	1332.00	33.20	23.07	2010.840	5	0.08	0.06	
				33.02	23.02	2001.062				CMC14
				33.09	23.02	2000.900				UCAC4
				33.08	33.08	1997.800				2MASS
	J 1929CD	0613.90	1333.00	30.90	9.26	2010.842	5	0.22	0.04	
07000+5913	STI 631	0700.90	5913.00	75.10	7.67	2011.216	10	0.49	0.27	
07010+2304	J 2449AC	0701.70	2303.00	339.10	18.24	2011.216	11	0.48	0.16	
07013+2351	POU2269	0701.90	2349.00	125.90	11.85	2011.216	11	1.57	0.29	12
07012+2304	POU2270	0701.90	2303.00	228.20	14.43	2011.216	9	0.62	0.27	13
07016+2337	POU2288	0702.30	2336.00	101.80	14.16	2011.216	11	1.29	0.58	
07016+2258	POU2290	0702.30	2257.00	40.60	14.77	2011.216	9	0.44	0.12	14

*Table concludes on next page.*

### Double Star Measurements for 2010/2011

WDS ID	Discoverer	RA	DEC	PA	SEP	Epoch	No.	PAsd	SEPsd	Notes
07027+2322	HJ 408	0703.30	2321.00	74.10	14.93	2011.216	9	0.33	0.07	
07026+2253	POU2320	0703.30	2252.00	188.20	8.31	2011.216	4	1.21	0.24	
07034+2252	POU2341AB	0704.10	2251.00	93.20	8.82	2011.216	5	0.8	0.36	
07037+2407	POU2351	0704.40	2407.00	289.20	5.93	2011.216	10	1.26	0.46	
07037+2304	POU2352	0704.40	2304.00	270.30	10.42	2011.216	5	0.86	0.12	
12042+1635	COU 52	1204.80	1631.00	74.50	5.53	2011.380	5	0.5	0.3	
12185+5725	STI2280	1219.00	5720.00	175.50	20.86	2011.375	5	0.23	0.09	
12375+0843	BRT3218	1238.10	839.00	355.50	7.23	2011.380	5	0.76	0.19	
12391+2344	POU3129	1239.60	2340.00	137.40	13.63	2011.380	5	1.64	0.11	
12469+2959	LDS4265	1247.40	2956.00	230.80	7.76	2011.380	5	0.57	0.17	
12473+2959	LDS4268	1247.80	2957.00	56.10	5.50	2011.380	5	0.34	0.17	
12534+1758	HJ 218	1255.90	1755.00	276.30	12.80	2011.380	5	0.13	0.13	
14035+0227	SLE 925	1404.10	224.00	131.30	12.31	2011.451	5	0.49	0.12	
14037+3846	ALI1091	1404.20	3843.00	187.50	10.21	2011.451	5	0.44	0.08	
14040+1318	BPM 611 ?	1405.30	1342.00	258.70	22.33	2011.451	4	0.32	0.13	15
14051+1917	UC 190	1405.70	1914.00	46.60	20.98	2011.451	5	0.06	0.03	16
14060+5335	STI2306	1406.40	5332.00	89.60	14.06	2011.451	5	0.3	0.04	
14162+3235	TOB 132BC	1416.70	3233.00	346.90	18.68	2011.452	5	0.31	0.05	
14170+5044	DAM 79	1417.40	5041.00	54.20	13.10	2011.452	5	0.46	0.12	
14211+4942	UC 193	1421.50	4939.00	317.10	9.55	2011.452	5	0.49	0.16	17
14232+7607	LDS1790	1423.20	7604.00	164.20	131.82	2011.452	5	0.18	0.25	18
14230+3616	HJ 548AB	1423.40	3611.00	249.00	136.63	2011.452	5	0.06	0.17	
	HJ 548AC	1423.40	3611.00	286.60	123.23	2011.452	5	0.04	0.15	
	HJ 548AD	1423.40	3611.00	314.00	151.13	2011.452	5	0.06	0.14	
	HJ 548AE	1423.40	3611.00	347.50	134.29	2011.452	5	0.04	0.2	
	HJ 548AF	1423.40	3611.00	26.60	122.72	2011.452	5	0.04	0.16	
14372+7537	LDS1803	1437.10	7534.00	136.60	18.21	2011.457	5	0.46	0.1	
14397+1150	LDS 966	1440.20	1147.00	122.40	21.62	2011.457	6	0.35	0.12	
14408+6109	STI 769	1441.10	6107.00	289.20	13.63	2011.457	5	1.19	0.19	
14474+6321	STI 775	1447.60	6318.00	169.60	7.88	2011.457	3	0.12	0.24	

## NOTES:

- Stein (STI) doubles were originally measured on blue sensitive plates. CCD and visual observations often reverse the magnitudes of the primary and secondary and this is the case here. "A" star is UCAC3 292-075838 catalog magnitude 12.04. "B" star is 292-075836 catalog magnitude 11.46.
- POU541 was not visible on my CCD image or POSSII plate. I'm reporting UCAC3 230-030956 as the "A" star and 230-030960 as "B". Match is fairly good to the 1897 measure and magnitudes, but not to the 1955 measurement.
- STI2096- "A" star is UCAC 290-082886.
- POU696- Position seems wrong. I'm measuring "A" star as UCAC3 227-036918 05 31. Position 54.12+23 12 36.1 and "B" star as UCAC3 227-036924, which seems to be a good match in PA and SEP.
- STI567- Only one previous measurement. "A" star is UCAC3 307-077823.
- POU741AB and POU 742AC POU 742AC see discussion section.
- POU754-Addition measurements extracted from Vizier: 1997.960 SEP 13.82 PA 349.79 ii/246 2MASS, 2000.21 SEP 14.149 PA 350.234 i/315 UCAC3, WDS 1951.854 Gellera has high residuals.
- POU786 "A" star is high proper motion TYC 1862-1151-1. Additional measurements extracted from Vizier: 1989.78 SEP 7.902 PA 261.248 I/289 UCAC2, 2000.101 SEP 7.937 PA 260.15 ii/246 2MASS, 2001.00 SEP 7.895 PA 260.251 I/315 UCAC3, WDS 1951.854 Gellera has high residuals.
- POU794- "B" star is much brighter in CCD image. "B" is UCAC3 230-043645 catalog mag 13.15. "A" star is 230- (Continued on page 10)

## Double Star Measurements for 2010/2011

- (Continued from page 9)*
- 043647 catalog mag 13.95.
10. POU805-Not at listed position. I'm measuring UCAC3 229-046017 as "A" star, position 05 53 19.93+24 19 12.3 and "B" star as 229-046013.
  11. POU818-Visual and CCD magnitudes are fainter. "A" star is UCAC3 227-043864 mag 14.26, "B" star is 227-043868 catalog mag 14.18.
  12. POU2269-Faint! "A" star is UCAC3 228-078872, catalog mag 15.37. "B" star is 228-078878, catalog mag 14.75.
  13. POU2270- Position wrong. I'm measuring "A" star as UCAC3 227-076190, position 07 01 14.1+23 03 51.3. "B" star is 227-076186
  14. POU2290-"B" star is brighter. "A" star is UCAC3 226-077656, catalog mag 13.43. "B" is 226-077662, catalog mag 13.12.
  15. BPM611-Not at listed position. I'm measuring "A" star as UCAC3 208-120316, Position 14 04 44.20+13 45 17.7. "B" star is 208-120315.
  16. UC190-Likely CPM. "A" star is TYC 1471 579, PM in RA -38 DEC 47, "B" PM in RA -49 DEC 49.
  17. UC193-Likely CPM. Similar proper motions.
  18. LDS1790- Large, but different proper motions. "A" star is TYC 4559 2322, PM in RA-92, PM DEC 14. "B" star is UCAC3 333-031157 PM in RA -68.8, DEC 35.8

*(Continued from page 6)*

### Results

Table 1 shows the results for the 100 doubles measured.

### Discussion

One interesting double observed was J1929 AB and J1929 AC. Both were discovered by Jonckheere in 1941. When I observed the pairs in 2010, I immediately noticed a striking four-star asterism (see Figure 1). Jonckheere measured the "C" star, but did not, for some reason, include the "D" star, which is just as bright. The "A" star is 4UC518-022223. The "B" star is 4UC518-022220. The "C" star is 4UC518-022227, and the new "D" star is 4UC518-022230 with a catalog magnitude of 13.49.

Rectilinear Elements for J1929AC:

X0	-2.49304
XA	0.00226802
Y0	1.07731
YA	0.00548316
T0 lowest residual	4259.18
T0 average	4266.65
T0 standard deviation	10.9526
rho0	2.71585
theta0	113.37
relative motion x	-2.26802
relative motion y	5.48316
total relative motion	5.93372

R^2	0.97788
F-Statistic	221.119
P-Value	0.0000248841

The relative motions are in good agreement with UCAC4. The original Jonckheere measurement of the AB pair had high residuals compared with the rest of the measurements in WDS and was not used in the regression.

### Conclusions on J1929

The AB and AC pairs are likely optical. The J1929 "B" and "C" stars have similar proper motions and may be a CPM pair. Probability indicates the new "D" star is likely associated with J1929C, but there is little other astrophysical data available.

### Acknowledgements:

As usual, thanks to Dr. Mason and Dr. Hartkopf for being willing to work with amateurs and for answering numerous data requests. Special thanks to my sister Gail Smith for proofreading this article. Thanks to Brian Skiff of Lowell Observatory for a tutorial on extracting historical measures from Vizier.

This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory.

### References

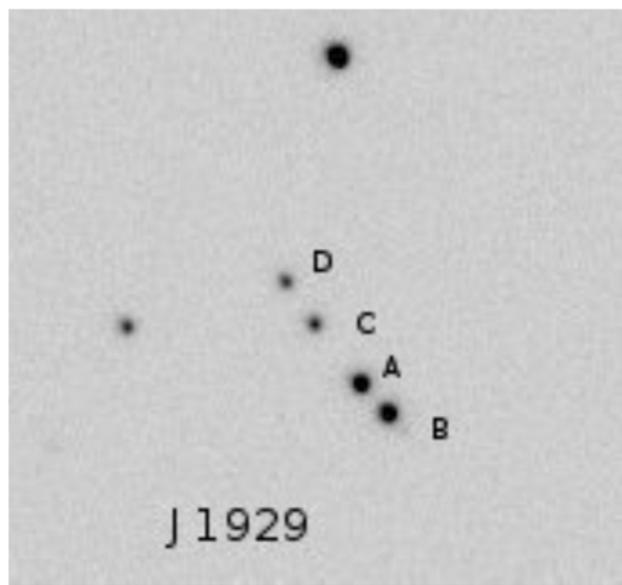
iTelescopes. <http://www.itelescope.net/>

### Double Star Measurements for 2010/2011

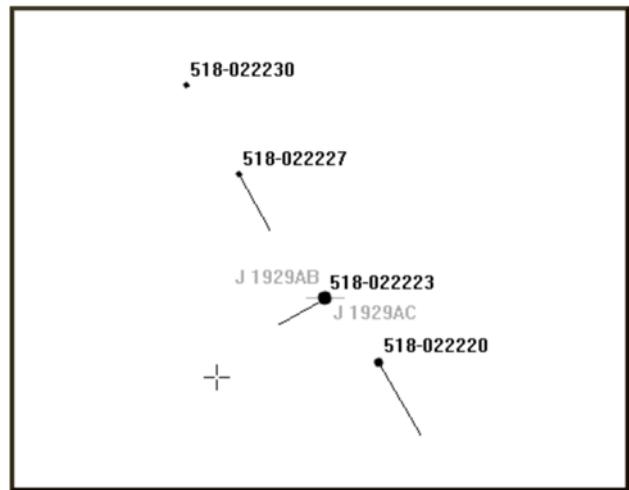
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*Figure 1. J1929 AB & AC shows four components in CCD image.*



*Figure 2. Guide 9 map of J1929AB and AC with 1000 year proper motion tracks.*

# Double Stars at the U.S. Naval Observatory

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**Abstract:** Micrometer measures of double stars made with the 24-inch reflector and the 26-inch refractor of the U.S. Naval Observatory from 1973 to 1990 are presented.

## Introduction

Alan Behall (1940-2009) worked at the US Naval Observatory from 1963-1975 in the Astronomy & Astrophysics Department in work primarily involving double stars. From 1968 to 1970, he made measures of 159 pairs with the 12 inch Clark refractor on the roof of Building 1 and obtained 68 mean positions with a median separation of 1.39 a.s. After his “training” period with the 12 inch, Alan began work with the 26 inch Clark refractor. From 1970 to 1974 he made measures of 1295 pairs with the 26 inch and obtained 370 mean positions with a median separation of 1.20 a.s. In 1974 he also made measures of 60 pairs with the 24 inch Boller & Chivens reflector, resulting in 24 mean positions with a median separation of 1.01 a.s. All of these measures are found in the second series of USNO Publications (Behall 1977).

However, his in-depth analysis of orbit pairs is probably of greater significance. In 1963 he determined a very accurate orbit for 13 Ceti (Behall 1963), and returned to it a decade later (Gatewood & Behall 1975) with George Gatewood to investigate the residuals in parallax measures due to the unseen spectroscopic companion in this overluminous star. He later collaborated with Charles Worley (Worley & Behall 1973), determining the orbit of the faint red double L726-8 observed with the 61 inch parallax program. He continued his work on this pair, collaborating with Bob Harrington (Harrington & Behall 1973) determining their mass ratio. Also with Harrington (Harrington & Behall 1976), he investigated the Keplerian perturbation of the



Figure 1. Alan Behall, USNO staffphoto (August 1968).

<sup>1</sup>Deceased: 11 June 2009

## Double Stars at the U.S. Naval Observatory

*Table 1. Statistics of Samples*

<b>Name</b>	<b>Dataset</b>	<b>Means</b>	<b>Measures</b>	<b>Separation (<math>\rho</math>)</b>			<b>Magnitude Difference (<math>\Delta m</math>)</b>			<b>Years</b>
				<b>Mean</b>	<b>Median</b>	<b>Minimum</b>	<b>Mean</b>	<b>Median</b>	<b>Maximum</b>	
<b>Behall 1977</b>		462	1515	1.40	1.23	0.24	0.9	0.6	4.3	1968-1975
<b>pre-retirement</b>		267	446	1.14	0.93	0.14	0.9	0.7	4.1	1973-1975
<b>post-retirement</b>		125	157	1.63	1.13	0.30	0.3	0.2	0.4	1984-1990

faint red dwarf pairs, G96-45 and G146-72, determining orbits that are still the standard. This was done in conjunction with his work on the parallax program (Harrington et al. 1976).

After Alan retired, he had subsequent careers as a computer programmer for two other branches of the Federal Government, the Office of Personnel Management and the Veteran Administration. But even after Alan left the USNO, he maintained an interest in double star research and returned periodically from 1984 to 1990 to observe and make micrometer measures. His observing program on the 26 inch only ended when the USNO mothballed its visual micrometry program in favor of speckle interferometry.

### Results

After the cutoff date of his earlier publication (Behall 1977), additional measures were made before he left the USNO: 36 mean positions with a median separation of 1.13 a.s. with the 24 inch and 231 mean positions with a median separation of 0.82 a.s. with the 26 inch.

The final set of “post-retirement” measures were delayed for some time. Of the 44 nights he observed from 1984 to 1990, Alan retained observing reports for only 12 of them. The reports for the remaining nights were apparently mishandled and the publication of these data have been delayed in a vain search through the USNO archives and double star papers of Charles Worley, who was in charge of the visual double star program.

All of the mean positions in the “pre” and “post” retirement are presented in Table 2. In this table, the first two columns identify the system by providing its epoch-2000 coordinates and discovery designation. Columns three through seven give the parameters of the mean position, the epoch of observation (expressed as a fractional Besselian year), the position angle (in degrees), the separation (in seconds of arc), the magnitude difference (in visual, when determined), and the number of individual measurements in the mean. Column eight gives the telescope aperture in inches indicating either the 24 inch Boller & Chivens reflector or the 26 inch Clark refractor. Finally, col-



Figure 2: Alan Behall, USNO luncheon (September 2002).

umn nine is reserved for notes which are listed at the end of the table.

Compilation of the measurements and brief description prepared by Brian Mason.

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**Double Stars at the U.S. Naval Observatory***Table 2. Measurements of Double Stars*

<b>WDS Desig. α, δ (2000)</b>	<b>Discoverer Designation</b>	<b>Epoch 1900.+</b>	<b>θ (°)</b>	<b>ρ ('')</b>	<b>Δm (V)</b>	<b>n</b>	<b>Tel. Aper. (inches)</b>	<b>Note</b>
00028+0208	BU 281 AB	75.698	172.1	1.50	3.0	2	26	
00028+0208	BU 281 AB	88.883	169.5	1.43		1	26	
00028+0208	BU 281 AB	89.899	167.3	1.57		1	26	
00029+2844	MLB 509	89.899	321.9	3.14		1	26	
00039+2759	A 429 AB	84.892	334.2	0.60		2	26	Q
00039+2759	HJ 1929 AC	84.892	289.3	5.27		2	26	
00047+3416	STF 3056 AB	75.698	142.2	0.59	0.0	2	26	
00047+3416	STF 3056 AB	84.892	144.6	0.81		2	26	
00049+3005	A 1250 AB	75.275	55.4	0.58	2.0	2	26	
00084+1843	COU 246	84.892	250.5	1.58		2	26	
00084+1843	COU 246	89.899	251.7	1.71		1	26	
00095+1907	COU 247	88.883	114.3	0.32		1	26	T
00121+5337	BU 1026 AB	74.718	354.1	0.31	1.0	1	26	
00137+0635	BU 998	88.883	109.5	1.41		1	26	
00137+0635	BU 998	89.899	108.9	1.31		1	26	
00149+2133	BU 1027	89.899	188.5	1.51		1	26	
00162+1903	J 217	88.883	178.8	1.67		1	26	
00162+1903	J 217	89.899	151.8	0.51		1	26	T
00167+3629	STT 4	74.718	181.7	0.59	0.8	1	26	
00167+3638	STF 19	74.718	138.2	2.22	2.0	1	26	
00187+1559	STF 25 AB	75.657	191.5	1.24	0.1	1	26	
00187+1559	STF 25 AB	88.883	193.6	1.33		1	26	
00187+1559	STF 25 AB	89.899	192.6	1.09		1	26	
00209+1059	BU 1093	75.657	107.6	0.70	0.7	1	26	
00209+3259	AC 1	75.657	287.8	1.71	0.5	1	26	
00248+1925	BRT 2296	89.899	186.7	3.04		1	26	
00287+2134	HU 601	88.883	308.7	0.48		1	26	
00287+2134	HU 601	89.899	304.3	0.43		1	26	
00345-0433	D 2 AB	75.657	259.7	0.47	0.5	1	26	
00352-0336	HO 212 AB	75.657	238.5	0.26	0.6	1	26	
00424+0410	STT 18 AB	75.657	190.6	1.60	2.0	1	26	
00550+2338	STF 73 AB	75.657	239.7	0.54	0.5	1	26	
00583+2124	BU 302	75.657	153.8	0.47	1.4	1	26	
01038+0646	A 2004	84.896	246.2	1.56		1	26	
01040+3528	HO 213	84.896	102.8	0.36		1	26	
01055+2107	AG 14	84.896	350.9	0.49		1	26	
01137+0735	BU 1029 BC	75.657	83.5	1.38	3.5	1	26	
01158+0947	A 2102	84.896	109.4	0.39		1	26	T
01189+0439	BAR 2	84.896	352.2	1.35		1	26	

**Double Stars at the U.S. Naval Observatory***Table 2 (Continued). Measurements of Double Stars*

WDS Desig. $\alpha, \delta$ (2000)	Discoverer Designation	Epoch 1900.+	$\theta$ ( $^{\circ}$ )	$\rho$ ( $''$ )	$\Delta m$ (V)	n	Tel. Aper. (inches)	Note
01198-0031	STF	113A, BC	75.657	9.1	1.64	1.0	1	26
01276+2104	COU	148	84.893	251.7	1.37		3	26
01277+0521	BU	1164 AB	75.657	159.2	0.44	0.3	1	26
01297+2250	A	1910 AB	75.657	148.7	0.21	0.0	1	26
01360+0739	STF	138 AB	75.657	53.2	1.66	0.5	1	26
01360+0739	STF	138 AB	84.888	54.8	1.67		3	26
01377+1836	COU	254	84.888	24.9	2.10		3	26
01467+3310	STF	158 AB	84.893	269.4	2.30		3	26
01498+3304	BU	1016	84.893	213.9	0.62		3	26
01532+1526	BU	260	84.893	257.6	1.13		3	26
01532+1526	BU	260	89.899	257.2	1.24		1	26
01593+2450	STF	194	89.899	277.9	1.28		1	26
01596+2100	STF	196 AB	89.899	42.2	2.21		1	26
02020+0246	STF	202 AB	74.808	286.5	1.80	0.9	1	26
02037+2556	STF	208 AB	89.899	326.5	0.94		1	26
02218+3830	STT	40	84.891	50.0	0.55		1	26
02313+4703	A	968	84.891	25.4	1.68		1	26
02388+3325	STF	285	84.892	162.7	1.78		2	26
02429-0629	A	452	84.892	112.2	1.95		2	26
02447-0158	STF	303	84.891	181.6	5.60		1	26
03023+1820	A	2414	84.893	55.5	0.57		1	26
03066+0046	A	2416	84.893	6.5	0.70		1	26
03216+2145	HU	434	84.893	200.0	0.36		1	26
03282+0409	A	2417 BC	84.895	119.2	0.96		2	26
03354+3529	POP	83	84.893	268.6	0.57		1	26
03354+3529	POP	83	84.896	269.8	0.63		1	26
03356+3141	BU	533 AB	75.038	221.4	1.00	0.2	1	26
03372+0121	A	2419	75.038	96.8	0.59	0.0	1	26
03401+3407	STF	425	75.038	76.4	1.73	0.1	1	26
03446+3210	BU	880 AB	84.895	12.0	0.54		2	26
03446+3551	HO	504	75.038	191.1	1.18	0.3	1	26
03463+2411	BU	536 AB	84.893	182.2	1.02		1	26
03503+2535	STT	65	74.990	206.3	0.56	0.3	2	26
03514+2538	HEI	9	84.895	282.0	4.21		2	26
03565+3311	BU	263	74.990	95.3	0.56	0.2	2	26
04038+2824	COU	701	84.893	207.9	1.71		1	26
04075-0657	A	468	84.893	197.9	0.86		1	26
04076+3804	STT	531 AB	75.090	13.2	1.47	2.2	2	26
04091+1046	HU	301	84.893	284.2	0.63		1	26

**Double Stars at the U.S. Naval Observatory***Table 2 (Continued). Measurements of Double Stars*

<b>WDS Desig. α, δ (2000)</b>	<b>Discoverer Designation</b>	<b>Epoch 1900.+</b>	<b>θ (°)</b>	<b>ρ ('')</b>	<b>Δm (V)</b>	<b>n</b>	<b>Tel. Aper. (inches)</b>	<b>Note</b>
04139+0916	BU 547 AB	75.113	345.3	1.24	2.3	3	26	
04139+0916	BU 547	84.893	344.6	1.34		1	26	
04233+1123	STF 535	75.113	294.6	1.30	1.5	3	26	
04268+5539	STF 531	75.038	318.1	1.10	1.5	1	26	
04301+1538	STF 554	75.113	18.9	1.72	2.3	3	26	
04335+1801	STF 559	75.113	276.4	3.04	0.2	3	26	
04366+1946	STT 86	75.151	18.8	0.52	0.0	2	26	
04518+1339	BU 552 AB	75.159	351.8	0.57		1	26	
04528-0517	BU 316	75.151	0.4	0.79	0.0	2	26	
04528-0517	BU 316	88.883	3.8	0.97		1	26	
05005+0506	STT 93	75.151	248.4	0.80	1.3	2	26	
05079+0830	STT 98	75.151	32.8	0.72	0.9	2	26	
05118+0102	STF 652	75.151	181.4	1.70	1.6	2	26	
05167+1826	STF 670 AB	75.151	166.6	2.52	0.5	2	26	
05239-0052	WNC 2 A, BC	75.151	161.5	2.65	0.9	2	26	
05239-0052	A 847 BC	75.151	319.4	0.28	0.0	2	26	
05245-0224	DA 5 AB	75.151	81.8	1.68	1.0	2	26	
05301+2933	STF 719 AB	75.151	333.9	1.16	2.4	2	26	
05309+1015	STF 726	75.151	262.3	1.08	0.5	2	26	
05312+0318	STF 729 AB	75.151	24.5	1.97	1.2	2	26	
05371+2655	STF 749 AB	75.142	330.5	1.11	0.0	1	26	
05407-0157	STF 774 AB	75.142	164.0	2.35	2.0	1	26	
05479+0758	STT 119	75.142	345.2	0.59	0.8	1	26	
05480+0627	STF 795	75.142	210.1	1.40	0.2	1	26	
05589+1248	STT 124	75.142	301.3	0.46	1.5	1	26	
06097+2914	A 54 AB	74.201	335.6	0.40	1.5	1	26	
06133+2902	A 56	74.201	60.1	1.02	3.5	1	26	
06327-0520	BU 98	75.159	150.5	0.57	0.0	1	26	
06344+1445	STF 932	75.159	316.0	1.94	0.1	1	26	
06396+2816	STT 152	75.159	32.9	0.97	1.8	1	26	
06474+1812	STT 156	74.680	250.7	0.47	0.5	2	26	
06478+0020	STT 157	75.159	228.3	0.32	0.3	1	26	
06541-0551	STF 987	75.159	173.3	1.47	0.2	1	26	
06585-0301	BU 327 AB	74.717	101.1	0.59	0.5	3	26	
07018-1053	BU 573	75.151	290.0	0.68	0.5	2	26	
07052-0052	A 1741	75.151	19.3	0.97	0.4	2	26	
07067-1118	BU 328 AB	75.151	112.3	0.50	2.0	2	26	
07128+2713	STF 1037 AB	75.151	324.7	1.41	0.2	2	26	
07138+2830	STT 520	75.142	14.9	0.44	2.0	1	26	

**Double Stars at the U.S. Naval Observatory***Table 2 (Continued). Measurements of Double Stars*

<b>WDS Desig. α, δ (2000)</b>	<b>Discoverer Designation</b>	<b>Epoch 1900.+</b>	<b>θ (°)</b>	<b>ρ ('')</b>	<b>Δm (V)</b>	<b>n</b>	<b>Tel. Aper. (inches)</b>	<b>Note</b>
07176+0918	STT 170	74.819	89.1	1.20	0.3	2	26	
07241+2127	STF 1081 AB	75.151	230.2	1.71	0.9	2	26	
07274+1519	STF 1094	75.142	97.3	2.65	1.0	1	26	
07279-1133	BU 332 AB	74.650	170.8	0.62	2.0	2	26	
07346+3153	STF 1110 AB	75.142	112.9	1.76	1.0	1	26	
07431+0011	A 2534 AB,C	74.157	225.6	0.66	2.5	1	26	
07461+2107	HO 247	74.157	221.3	0.45	0.3	1	26	
08033+2616	STT 186	74.223	72.9	0.68	0.6	1	26	
08122+1739	STF 1196 AC	90.282	79.0	6.07		1	26	
08267+2432	STF 1224 A,BC	90.282	49.7	5.42		1	26	
08413+2029	BU 585	74.223	89.0	0.55	1.5	1	26	
08427+2603	HO 354	90.282	184.8	0.88		1	26	
08461+0748	J 735	90.282	338.9	2.80		1	26	
08468+0625	STF 1273 AB,C	90.282	288.2	2.60		1	26	
08542+3035	STF 1291 AB	74.223	316.4	1.51	0.5	1	26	
08542+3035	STF 1291 AB	90.282	311.7	1.58		1	26	
08593+3457	STF 1296	90.282	76.1	1.97		1	26	
09006+4147	KUI 37 AB	74.201	122.7	0.43	2.0	1	26	
09020+0240	BU 211	90.282	268.9	1.05		1	26	
09245+1808	A 2477	74.223	324.4	0.55	1.5	1	26	
09296-0307	BU 591	74.223	28.6	0.70	1.0	1	26	
09415+1753	A 2481	74.201	6.2	0.31		1	26	
09435+0612	A 2761	74.201	249.6	0.57	0.1	1	26	
09500+1634	STF 1385	74.201	336.4	1.10	2.5	1	26	
09599+1610	A 2482	74.201	29.0	0.63	1.0	1	26	
10040+3239	HU 631	74.201	262.7	0.67	1.5	1	26	
10056+3105	STF 1406	74.201	222.6	0.70	1.0	1	26	
10109+0742	A 2565	74.201	261.6	1.24	2.5	1	26	
10131+2725	STT 213	74.691	137.1	0.72	1.6	2	26	
10151+1907	STF 1417	74.691	76.9	2.42	0.1	2	26	Q
10163+1744	STT 215	74.348	186.1	1.23	0.4	1	24	
10163+1744	STT 215	75.159	184.1	1.62	0.4	2	26	
10192+2034	STF 1423	75.159	13.2	1.08	0.6	1	26	
10200+1950	STF 1424 AB	75.159	124.1	4.28	1.5	1	26	
10205+0626	STF 1426 AB	90.282	307.7	0.91		1	26	
10205+0626	STF 1426 BC	90.282	13.5	7.49		1	26	
10227+1521	STT 216	90.282	243.5	1.71		1	26	
10250+2437	STF 1429	75.159	190.8	0.63	0.0	1	26	
10250+2437	STF 1429	90.282	176.2	0.67		1	26	

**Double Stars at the U.S. Naval Observatory***Table 2 (Continued). Measurements of Double Stars*

WDS Desig. $\alpha, \delta$ (2000)	Discoverer Designation	Epoch 1900.+	$\theta$ ( $^{\circ}$ )	$\rho$ ( $''$ )	$\Delta m$ (V)	n	Tel. Aper. (inches)	Note
10260+0256	A 2570	74.691	310.7	0.46	0.0	2	26	
10301+2048	STF 1439	90.282	84.3	1.50		1	26	
10305+1444	J 736	90.282	198.8	2.78		1	26	
10387+0544	STF 1457	75.159	327.4	1.93	0.8	1	26	
10417+1044	STT 227	75.159	359.8	0.83	0.6	1	26	
10417+1044	STT 227	90.282	3.8	0.97		1	26	
10480+4107	STT 229	74.368	287.9	0.61	0.3	1	24	
10493-0401	STF 1476	74.764	11.8	2.20	0.7	1	24	
10493-0401	STF 1476	75.159	11.0	2.31	0.7	1	26	
11000-0328	STF 1500	75.151	304.4	1.69	1.8	2	26	
11040+0338	STF 1504	74.368	116.0	0.93	0.1	1	24	
11040+0338	STF 1504	75.151	117.6	1.32	0.2	2	26	
11137+2008	STF 1517 AB	75.151	152.0	0.38	0.1	2	26	
11182+3132	STF 1523 AB	74.368	117.8	3.05	0.0	1	24	
11182+3132	STF 1523 AB	75.151	116.7	2.93	0.5	2	26	
11190+1416	STF 1527	75.151	30.7	1.65	1.1	2	26	
11190+1416	STF 1527	86.353	45.1	0.97	0.2	1	26	
11230+0408	A 2776 AB	75.159	251.0	0.19	0.0	1	26	
11239+1032	STF 1536 AB	86.353	135.6	1.25	0.1	1	26	
11300+0312	BU 340	86.353	10.7	4.55	0.3	1	26	
11363+2747	STF 1555 AB	75.151	142.6	0.46	0.3	2	26	
11428+2105	HU 888	75.159	168.2	0.41	0.5	1	26	
11428+2105	HU 888	86.353	163.4	0.45	0.3	1	26	
11563+3527	STT 241	75.142	140.4	1.87	2.0	1	26	
12108+3953	STF 1606	86.353	245.6	0.36	0.2	1	26	
12159-0759	A 143 AB	86.353	141.9	1.02	0.4	1	26	
12244+2535	STF 1639 AB	75.159	329.7	1.55	1.0	1	26	
12291+3123	STT 251	86.353	60.8	0.49	0.4	1	26	
12306+0943	STF 1647	86.353	245.7	1.47	0.4	1	26	
12351+0727	STF 1658 AB	74.772	12.6	2.60	2.0	2	26	
12360+1124	STF 1661	86.353	249.2	2.31	0.2	1	26	
12372+2112	STF 1663	74.318	84.2	0.59	0.8	1	24	
12372+2112	STF 1663	75.159	82.1	0.57	1.0	1	26	
12409+0850	STF 1668	75.159	189.3	1.37	0.5	1	26	
12417-0127	STF 1670 AB	75.159	301.7	4.18	0.0	1	26	
12441+3546	HO 256	74.384	118.2	0.86	2.0	1	26	
12501+2408	A 563	74.384	194.6	0.46	0.7	1	26	
13039-0340	BU 929	75.452	203.9	0.64	0.4	1	26	
13081+2657	STT 260	75.452	160.3	0.29	0.2	1	26	

**Double Stars at the U.S. Naval Observatory***Table 2 (Continued). Measurements of Double Stars*

WDS Desig. $\alpha, \delta$ (2000)	Discoverer Designation	Epoch 1900.+	$\theta$ ( $^{\circ}$ )	$\rho$ ( $''$ )	$\Delta m$ (V)	n	Tel. Aper. (inches)	Note
13091+2127	HU 572	75.452	199.8	0.17	1.0	1	26	
13100+1732	STF 1728 AB	74.384				1	26	E
13189+0030	A 2585 AB	74.392	223.3	0.79	0.3	2	26	
13203+1746	A 2166	75.452	126.2	0.16		1	26	U
13207+0257	STF 1734	75.434	180.3	1.03	0.5	2	24	
13243+0124	STF 1742	75.449	356.0	1.13	0.6	1	24	
13243+0124	STF 1742	75.452	356.0	1.14	0.6	1	26	
13347-1313	BU 932 AB	74.918	44.9	0.38	0.5	2	26	
13347-1313	BU 932 AB	75.449	53.7	0.27	0.3	1	24	
13375+3618	STF 1768 AB	75.434	101.9	1.87	2.0	2	24	
13375+3618	STF 1768 AB	75.452	106.8	1.70	2.5	1	26	
14139+2906	STF 1816	75.449	88.6	0.61	0.1	1	24	
14139+2906	STF 1816	88.445	92.1	0.71		1	26	
14153+0308	STF 1819 Aa,Ab	75.449	255.1	0.69	0.2	1	24	
14153+0308	STF 1819 Aa,Ab	75.474	254.7	0.57	0.2	1	26	
14158+1018	STF 1823 AB,C	75.474	147.7	3.96	1.0	1	26	
14203+4830	STF 1834	75.449	101.5	1.36	0.1	1	24	
14234+0827	STF 1835 A,BC	75.474	190.7	6.15	1.5	1	26	
14234+0827	BU 1111 BC	88.445	79.6	0.40		1	26	T
14323+2641	A 570	74.384	102.7		0.1	1	26	
14411+1344	STF 1865 AB	75.419	306.0	1.01	0.5	1	24	
14463+0939	STF 1879 AB	88.445	89.3	1.47		1	26	
14534+1542	STT 288	88.445	170.9	1.38		1	26	
14584+1508	OL 187	88.445	83.1	1.76		1	26	
15038+4739	STF 1909	75.449	20.7	0.45	1.0	1	24	
15126+1523	STF 1917	88.445	233.8	2.32		1	26	
15183+2650	STF 1932 AB	75.449	245.9	1.31	0.2	1	24	
15232+3017	STF 1937 AB	75.449	228.8	0.53	0.5	1	24	
15420+0027	A 2176	74.422	236.8	0.31	0.0	1	26	
16044-1122	STF 1998 AB	75.581	10.7	1.24	0.3	1	26	
16044-1122	STF 1998 BC	75.581	55.5	7.19	1.5	1	26	
16057-0617	BU 948 AB	75.581	113.6	1.22	2.3	1	26	
16071+1654	BU 812	75.581	107.5	0.65	0.2	1	26	
16076+2900	STF 2011 AB	88.445	69.5	2.28		1	26	
16128+2640	STF 2022	75.581	148.5	2.39	3.0	1	26	
16212+2259	HU 481	75.581	149.2	0.32	1.9	1	26	
16235+3321	VBS 26 AB	75.581	92.8	0.19	0.0	1	26	
16235+3321	BU 951 AB,C	75.581	31.3	0.97	0.5	1	26	
16238+6142	STF 2054 AB	75.257	351.1	0.81	1.0	3	24	

**Double Stars at the U.S. Naval Observatory***Table 2 (Continued). Measurements of Double Stars*

<b>WDS Desig. α, δ (2000)</b>	<b>Discoverer Designation</b>	<b>Epoch 1900.+</b>	<b>θ (°)</b>	<b>ρ ('')</b>	<b>Δm (V)</b>	<b>n</b>	<b>Tel. Aper. (inches)</b>	<b>Note</b>
16279+2559	STF 2049	75.581	197.7	1.16	1.0	1	26	
16279+2559	STF 2049	88.445	194.6	1.19		1	26	
16289+1825	STF 2052 AB	75.581	139.0	1.28	0.1	1	26	
16309+0159	STF 2055 AB	75.594	4.3	1.12	1.8	2	24	
16309+0159	STF 2055 AB	75.619	5.7	1.31	1.9	2	26	
16318-0701	STF 3105	75.581	210.1	0.23	0.0	1	26	
16413+3136	STF 2084	75.619	176.1	1.08	2.5	2	26	
16442+2331	STF 2094 AB	75.581	77.0	1.13	0.0	1	26	
16511+0924	STF 2106 AB	75.581	182.5	0.43	1.7	1	26	
16514+0113	STT 315	75.581	75.8	0.17	1.6	1	26	
16564+6502	STF 2118 AB	75.594	71.1	0.99	0.5	2	24	
16567+1408	STT 318	75.581	244.3	2.62	2.5	1	26	
16588+0358	STF 3107 AB	75.287	82.1	1.49	0.1	3	26	
17053+5428	STF 2130 AB	75.594	52.6	1.96	0.0	2	24	
17130+0745	STT 325	75.619	237.4	0.35	1.8	2	26	
17146+1423	STF 2140 AB	75.567	107.5	4.73	3.1	4	26	
17171+0726	A 1148	75.619	349.9	2.04	1.5	2	26	
17174+1113	HU 172	75.619	345.1	0.99	2.5	2	26	
17279+7112	A 1154	75.549	245.5	0.59	0.2	2	26	
17304-0104	STF 2173	74.622	111.8	0.42	0.3	1	26	
17304-0104	STF 2173	75.618	80.2	0.19	0.3	4	26	
17471+1742	STF 2215	75.618	269.3	0.45	2.1	4	26	
17520+1520	STT 338 AB	75.594	172.2	0.82	0.1	2	24	Q
18031-0811	STF 2262 AB	75.594	275.2	1.74	0.5	2	24	
18055+0230	STF 2272 AB	75.588	5.2	1.93	1.9	4	26	
18055+0230	STF 2272 AB	75.594	7.4	1.93	2.1	2	24	
18058+2127	STT 341 AB	75.618	97.7	0.24	1.2	4	26	
18070+3034	AC 15 AB	75.618	350.9	1.49	4.1	4	26	
18096+0400	STF 2281 AB	75.599	345.5	0.27	1.4	3	26	
18146+0011	STF 2294	75.618	94.5	1.09	0.3	4	26	
18197+1016	HU 197	75.599	156.0	0.24	0.9	3	26	
18201-0759	STF 2303	75.599	241.0	1.74	2.4	3	26	
18218+2130	BU 641	74.560	346.1	0.64	2.0	1	24	
18261+0047	BU 1203	75.619	140.5	0.33	0.4	2	26	
18305+2519	A 246	75.287	161.9	1.45	2.2	3	26	
18312+2516	A 248	75.657	29.3	0.35	0.5	1	26	
18320+0647	STT 354	75.619	192.1	0.70	0.7	2	26	
18338+1744	STF 2339 AB, CD	75.619	276.2	1.83	0.7	2	26	
18355+2336	STT 359	75.657	11.2	0.62	0.3	1	26	

**Double Stars at the U.S. Naval Observatory***Table 2 (Continued). Measurements of Double Stars*

<b>WDS Desig. α, δ (2000)</b>	<b>Discoverer Designation</b>	<b>Epoch 1900.+</b>	<b>θ (°)</b>	<b>ρ ('')</b>	<b>Δm (V)</b>	<b>n</b>	<b>Tel. Aper. (inches)</b>	<b>Note</b>
18413+3018	STF 2367 AB	74.622	58.3	0.28	0.5	1	26	
18439+0237	STF 2369	87.695	71.4	0.43		1	26	
18443+6103	STF 2403	75.058	275.4	1.19	3.0	2	24	
18570+3254	BU 648 AB	87.695	23.7	0.97		1	26	
18575+5814	STF 2438	75.243	1.1	0.77	0.5	3	26	
19121+0237	BU 1204 AB	75.659	180.7	0.28	0.9	2	26	
19159+2727	STT 371 AB	75.664	156.7	0.91	0.2	2	26	
19160+1610	STT 368 AB	75.664	218.5	1.01	1.2	4	26	
19346+1808	STT 375	75.756	172.1	0.43	1.5	1	26	
19363+3540	STT 377 AB	75.748	33.1	0.84	0.1	2	26	
19379+2248	A 164	75.688	237.8	0.25	1.5	4	26	
19384+0021	BU 249 AB	75.688	118.7	0.82	2.1	4	26	
19389+3514	HU 953	75.739	218.9	0.34	0.4	3	26	
19394+2215	STF 2556	75.688	40.7	0.33	0.4	4	26	
19413+3043	BU 145 AB	75.698	272.8	0.77	2.2	2	26	
19419+2723	STT 382	75.676	329.4	0.34	0.4	3	26	
19426+1150	STT 380 AB	75.676	77.4	0.40	1.1	3	26	
19449+1047	AGC 10	75.676	140.8	0.25	0.0	3	26	Q
19449+1047	STF 2570 AB,C	75.676	277.3	4.21	1.4	3	26	
19450+4508	STF 2579 AB	73.593	241.9	1.94	3.0	1	26	
19464+3344	STF 2576 FG	75.633	183.2	1.95	0.0	1	26	
19483+3710	STT 386	75.083	72.4	0.82	0.1	2	26	
19487+1149	STF 2583 AB	75.581	109.2	1.34	0.7	1	26	
19520-1021	BU 148 AB	75.581	258.1	0.50	0.3	1	26	
19540+1518	STF 2596	75.581	306.5	1.89	1.2	1	26	
19573+0513	A 604	75.581	90.5	0.20	0.0	1	26	
19575+2018	BU 425 AB	75.581	242.0	1.44	0.2	1	26	Q
19575+1408	A 1662	75.581	190.5	0.29	0.0	1	26	
19579+2715	AC 16 AB	75.581	229.8	0.34	0.5	1	26	
19580+0456	A 606	75.581	122.1	0.30	0.0	1	26	
19585+3317	STF 2606 AB	74.808	140.3	0.80	0.9	1	26	
20035+3601	STF 2624 AB	75.575	174.3	1.76	0.5	1	24	
20042+1148	STF 2620 AB	74.718	287.0	1.77	1.0	1	26	
20067+1256	BU 428	75.756	353.4	0.70	1.0	1	26	
20095+5140	STF 2645	75.575	139.5	1.31	0.4	1	24	
20108+1827	J 506	88.442	264.0	19.07		1	26	T
20117+1115	J 136	88.442	279.7	5.51		1	26	T
20137+2414	STF 2653	75.756	272.8	2.60	3.5	1	26	
20137+1609	STF 2651 AB	75.756	280.1	1.06	0.0	1	26	

**Double Stars at the U.S. Naval Observatory***Table 2 (Continued). Measurements of Double Stars*

WDS Desig. $\alpha, \delta$ (2000)	Discoverer Designation	Epoch 1900.+	$\theta$ ( $^{\circ}$ )	$\rho$ ( $''$ )	$\Delta m$ (V)	n	Tel. Aper. (inches)	Note
20153+2536	BU 983 AB	88.442	175.0	0.30		1	26	
20176+2622	BU 984	75.575	238.6	0.42	0.3	1	24	
20176+2622	BU 984	75.756	242.0	0.41	0.4	1	26	
20208-0745	SCJ 25	88.442	215.2	2.44		1	26	
20321+1511	A 1677	75.756	175.8	0.98	3.0	1	26	
20329+1357	L 35 CD	74.718	282.1	0.32	0.5	1	26	
20450+1244	BU 64 AB	88.442	164.1	0.67		1	26	
20456+1714	COU 425	88.442	316.9	0.61		1	26	
20478+0600	BU 65	88.442	194.8	1.49		1	26	
20514-0538	STF 2729 AB	74.770	9.1	1.17	1.2	1	24	
20557+0432	STF 2735	74.770	284.3	2.02	1.4	1	24	
21031+0132	STF 2744 AB	75.640	130.1	1.37	0.5	4	26	
21047+0332	STF 2749 A,BC	75.637	168.7	3.28	1.1	4	26	
21047+0332	SE 3 BC	75.638	224.6	0.25	0.5	3	26	
21120+2410	STT 430	75.637	197.7	1.31	2.1	4	26	
21209+0307	BU 838	88.710	144.9	1.57		1	26	
21214+1020	A 617	75.667	108.5	0.14	0.1	2	26	
21235+1728	COU 428	88.710	131.5	0.84		1	26	
21289+1105	STF 2799 AB	88.710	268.3	1.78		1	26	
21352+2124	BU 74	88.710	336.7	1.20		1	26	
21355+2427	HU 371	75.637	293.4	0.25	0.4	4	26	
21355+2427	HU 371	84.798	291.8	0.46		1	26	
21362+3003	BU 167	88.710	90.3	1.71		1	26	
21383+2336	HU 372	75.638	207.7	0.23	0.0	3	26	
21395-0003	BU 1212 AB	75.619	196.0	0.25	0.4	2	26	
21395-0003	BU 1212 AB	88.442	256.5	0.45		1	26	
21441+2845	STF 2822 AB	75.637	294.0	1.92	1.5	4	26	
21446+2539	BU 989 AB	75.638	119.9	0.27	0.3	3	26	
21446+2539	BU 989 AB	88.710	100.6	0.38		1	26	T
21448+0300	BU 689	88.710	241.7	1.36		1	26	
21461+2111	AG 277	88.710	58.8	2.88		1	26	
21501+1717	COU 14	75.657	263.8	0.24	1.5	1	26	
21555+1053	BU 75 AB	75.648	294.0	0.19	0.5	4	26	
21572+1047	A 622	75.667	322.1	0.21	0.3	2	26	
22044+1339	STF 2854	74.770	84.3	1.91	0.0	1	26	
22045+1551	BU 696 AB	84.798	356.4	0.33		1	26	
22071+0034	STF 2862	84.798	97.6	2.81		1	26	Q
22110+2429	EGG 4	84.846	154.7	0.49		2	26	
22126+3013	HO 179 AB	75.637	274.3	0.65	1.0	4	26	

**Double Stars at the U.S. Naval Observatory***Table 2 (Continued). Measurements of Double Stars*

<b>WDS Desig. α, δ (2000)</b>	<b>Discoverer Designation</b>	<b>Epoch 1900.+</b>	<b>θ (°)</b>	<b>ρ ('')</b>	<b>Δm (V)</b>	<b>n</b>	<b>Tel. Aper. (inches)</b>	<b>Note</b>
22145+0759	STF 2878 AB	74.770	118.9	1.28	1.8	1	26	
22146+2934	STF 2881	74.770	80.7	1.19	0.4	1	26	
22201+4625	A 185	84.893	131.5	0.68		1	26	Q
22237+2051	STF 2900 AB	75.619	59.9	0.16	3.0	2	26	
22288-0001	STF 2909 AB	74.770	238.7	1.79	0.2	1	24	
22295-0012	BU 76 AB	75.668	355.6	1.59	2.0	4	26	
22300+0426	STF 2912	84.893	119.3	0.76		1	26	
22329+4923	HU 1320	84.893	316.0	0.35		1	26	Q
22368+3123	A 1232	75.657	333.7	1.34	4.0	1	26	
22414+0443	BU 480	75.668	66.3	0.88	1.0	4	26	
22451-0240	A 2696 BC	84.893	101.3	0.52		1	26	
22478-0414	STF 2944 AB	74.770	281.7	2.28	0.5	1	24	
22514+6142	STF 2950 AB	74.770	291.6	1.63	1.3	1	24	
22537+4445	BU 382 AB	74.770	202.7	0.74	2.0	1	24	
22552-0459	BU 178	84.893	325.3	0.67		1	26	
22569+1151	STF 2958	75.668	11.0	3.75	2.4	4	26	
22592+1144	STT 483	75.668	288.8	0.53	1.5	4	26	
23067+3302	COU 741 Aa,Ab	84.893	169.1	0.92		1	26	
23102+5727	STT 490 AB	75.756	302.6	1.15	2.0	1	26	Q
23103+3229	BU 385	84.846	96.7	0.68		2	26	
23113+1144	ROE 133	75.657	325.8	2.14	0.8	1	26	
23121+0853	J 670	75.657	193.7	2.21	1.5	1	26	
23175+1652	HLD 171 A,BC	84.861	24.7	2.15		3	26	
23175+1652	HU 497 BC	84.893	140.1	0.30		1	26	
23189+0524	BU 80 AB	84.798	316.1	0.87		1	26	
23206+3621	POP 68 AB	84.891	318.4	0.88		1	26	
23208+2158	STT 494	84.892	82.5	3.32		2	26	
23277+7406	STF 3017 AB	75.716	25.3	1.48	1.1	2	26	
23322+0705	HU 298	84.892	302.1	0.36		2	26	
23340+3120	BU 720	84.892	86.1	0.72		2	26	Q
23413+3234	BU 858 AB	84.892	230.7	0.80		2	26	
23420+2018	STT 503 AB	84.892	133.8	1.23		2	26	
23425+5436	A 1495	75.716	173.2	0.41	0.2	2	26	
23431+1150	A 1242	84.892	327.7	0.91		2	26	
23453+0507	BU 1223	75.657	295.3	1.39	2.0	1	26	
23461+6028	STF 3037 AB	75.716	213.7	2.58	1.4	2	26	
23476+4650	BU 995	75.669	246.8	0.64	2.0	2	26	
23498+2741	A 424	75.657	93.6	0.19	0.0	1	26	
23595+3343	STF 3050 AB	74.770	302.2	1.44	0.0	1	24	Q

**Double Stars at the U.S. Naval Observatory***Table 2 (Continued). Measurements of Double Stars*

WDS Desig. $\alpha, \delta$ (2000)	Discoverer Designation	Epoch 1900.+	$\theta$ ( $^{\circ}$ )	$\rho$ ( $''$ )	$\Delta m$ (V)	n	Tel. Aper. (inches)	Note
23595+3343	STF3050 AB	75.663	301.5	1.50	0.0	4	26	Q
23595+3343	STF3050 AB	84.892	313.0	1.77		2	26	

## Table Notes:

Q : Quadrant reversed by the cataloger.

T : Identification error, position error, or typo.

E : Elongated, but too close to measure.

U : Uncertain.

*Editors Note: Alan Behall did the measures listed in this article, which was written by Brian Mason of the U.S. Naval Observatory.*



# Discovery of Small Companions of $\gamma$ Comae and TYC 1989-00307-1 in Constellation Coma Berenices and a Possible New Common Proper Motion Pair in the Constellation Canes Venatici

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**Abstract:** In the constellation Coma Berenices a new companion of the bright star  $\gamma$  Comae was found. Comparison with historical sky images shows that the companion is joined with the much brighter star. A companion of TYC 1989-00307-1 was also found. In the constellation Canes Venatici a possible common proper motion star was found.

## Report

During observations in spring 2013 in the constellations Coma Berenices and Canes Venatici, a new possible binary star and some possible new common proper motion pairs were found. Observations were made with a 12 inch Newtonian telescope in combination with a Canon digital single lens reflex camera (DSLR) 1100D. A 15 second exposure time was used to make the observations. The planetary software, Redshift 7, was used for telescope control. Data analysis was done with the software program REDUC [Losse].

The Tycho catalog and the USNO catalog list these new double stars as single stars. To obtain more information about the possible physical structure of these double stars the Aitken criterion and also Halbwach's criterion were checked. The Aitken criterion can be calculated if the brightness of both components is known. The given brightness can be interpreted as combined brightness. The difference in brightness of both components can be estimated. With this assumption the Aitken criterion can be calculated. The Aitken criterion gives a maximum separation ( $\rho_{\max}$ ) for both components. If the measured separation  $\rho$  is smaller than  $\rho_{\max}$  both components may be physically linked as binary star. The Aitken criterion is not a physical criterion,

[Romero, 2006]. Halbwach's criterion is helpful for searching possible common proper motion pairs. To calculate Halbwach's criterion, only proper motion and separation has to be known. If the ratio between measured separation and proper motion is less than 1000 years, the possibility for a common proper motion pair is nearly 99%. T is also the time which the star needs for moving the measured distance [Halbwach, 1986].

## Discovery of Small Companions of TYC 1989-00307-1 and $\gamma$ Comae

TYC 1989-00307-1 is listed in WDS catalog as ARN 6AD and is assigned to 12 Comae. It is near the center of the Coma Berenices star cluster. Separation between TYC 1989-00307-1 and 12 Comae is about 213 arc seconds. Proper motions of 12 Comae and TYC 1989-00307-1 are very different and therefore it has to be expected that both stars are not physically connected. At a distance of only 13.5 arc seconds from TYC 1989-00307-1, another possible component can be found. TYC 1989-00307-1 complies with Halbwach's criterion. Because of the difference in brightness of about 3 magnitudes between both components, TYC 1989-00307-1 doesn't look like a common proper motion pair.

## Discovery of Small Companions of $\gamma$ Comae and TYC 1989-00307-1 in Constellation Coma Berenices ...



Figure 1: Image of 12 Comae and TYC 1989-00307-1. The new component is marked with lines. The companion is not yet listed in WDS catalog. Image made by the author in 2013.431.

Gamma Comae is the brightest star in the open star cluster Coma Berenices. At a separation of only 16.2 arc seconds, a possible companion with a brightness of about 12 magnitudes can be found. This faint companion can also be found on images made with the Bruce telescope at Königstuhl observatory in Heidelberg/Germany in 1901 (see also Schlimmer 2012). Proper motion of  $\gamma$  Comae is about 117 mas/yr. In the time of 112 years,  $\gamma$  Comae changed its position of about 13.1 arc seconds. The relative position of the companion to  $\gamma$  Comae appears unchanged. Therefore, it can be expected that the companion has the same proper motion and is joined to  $\gamma$  Comae. Because of its brightness and its the proper motion  $\gamma$  Comae complies with Aitken criterion and also with Halbwach's criterion. On POSS 2 images this companion is outshined by the much brighter star [CDS].

### New Possible Common Proper Motion Pairs in Constellation Canes Venatici

USNO B1.0 1374-0287544 can be found in the neighborhood of the well known galaxy M51. In the USNO catalog B1.0, 1374-0287544 is listed as single star, but Figure 4 shows that it consists of two components with equal brightness. Proper motion is 25.6 mas/yr. With a separation of 7.2 arc seconds, the time T is

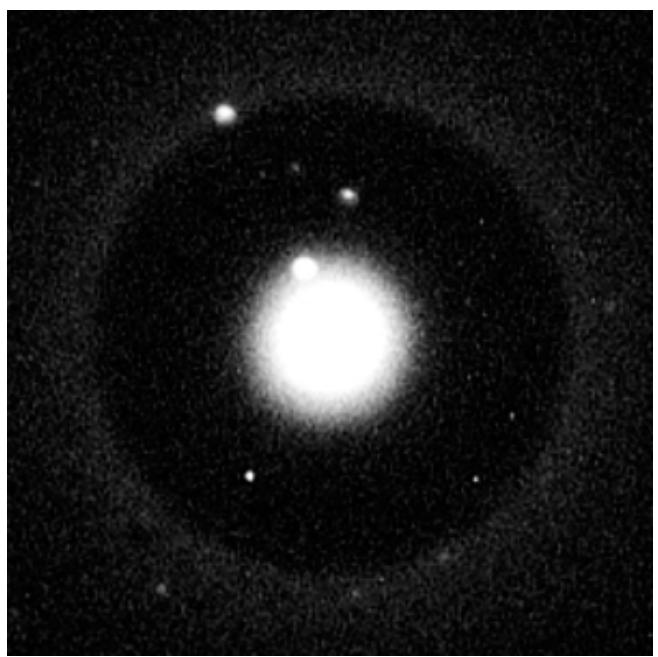


Figure 2: Image of  $\gamma$  Comae, made by Max Wolf (1863-1932) in 1901 with the Bruce telescope on Königstuhl observatory in Heidelberg, exposure time was 102 minutes [HDAP, B123a 1901-01-18].



Figure 3: Image of  $\gamma$  Comae with new companion made by the author in 2013.431. The companion is marked with lines and is not yet listed in WDS catalog

## Discovery of Small Companions of $\gamma$ Comae and TYC 1989-00307-1 in Constellation Coma Berenices ...



Figure 4: Possible common proper motion pair USNO B1.0 1374-0287544, image made by the author in 2013.431.



Figure 5: Image of USNO B1.0 1372-0290876 made by the author in 2013.431.

only 281 years. Because T is smaller than 1000 years, Halbwach's criterion for a possible common proper motion pair is satisfied.

USNO B1.0 1372-0290876 can also be found in the neighborhood of the galaxy M51. At a separation of 3.7 arc seconds another star can be found. The difference in brightness is about 0.5 magnitude. Aitken's criterion is not satisfied, so we can expect that this not a physical binary star. Proper motion is not known and therefore Halbwach's criterion cannot be calculated.

The double stars are listed in table 1. The first column lists the catalog name of the star, while the second and third columns are coordinates for R.A. and declination, the fourth column gives the bright-

ness, the fifth and sixth columns give the proper motion in mas/yr if known, in the seventh column is the estimated difference in brightness, the eighth and ninth columns give the calculated individual magnitudes, columns ten and eleven give the angle in degrees and separation between the components in arc seconds, the twelfth column shows the calculated Aitken limit  $p_{\max}$  in arc seconds, and the thirteenth column gives the time in years that the pair needs to move the distance of its own separation if proper motion is known. Finally, column fourteen gives a short note on the image field neighborhood.

### Acknowledgements

This research has made use of the SIMBAD data-

Table 1: New stellar pairs in constellation Coma Berenices and Canes Venatici.

Name	RA	Dek	Mag	PM R.A.	PM Dec.	Mag A	Mag B	Theta	P	Aitken limit	T=p/PM	Notes
TYC 1989-00307-1 = ARN 6AD	12 22 42.0	+25 48 22.56	10.07	42.80	-17.20	10.13	13.13	166.8	12.835	6.13	278.3	member of Melotte 111 near 12 Comae
$\gamma$ Comae	12 26 56.3	+28 16 06.3	4.34	-83.95	-81.13	4.34	12	203.8	16.2	85.5	138.8	member of Melotte 111
USNO B1.0 1374-0287544	13 31 28.5	47 26 12.1	12.6	-16	-20	13.35	13.35	121.7	7.18	1.91	281.1	near M51
USNO B1.0 1372-0290876	13 32 25.5	47 17 02.6	12.0	0	0	12.53	13.03	248.6	3.70	2.51		near M51

**Discovery of Small Companions of  $\gamma$  Comae and TYC 1989-00307-1 in Constellation Coma Berenices ...**

base, operated at CDS, Strasbourg, France. This work made use of the HDAP which was produced at Landessternwarte Heidelberg-Königstuhl under grant No. 00.071.2005 of the Klaus-Tschira-Foundation. This research has made use of the USNO Image and Catalogue Archive operated by the United States Naval Observatory, Flagstaff Station, (<http://www.nofs.navy.mil/data/fchpix/>). Finally, this research made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory.

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# A New Double Star from an Asteroidal Occultation: UCAC2 30429828

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**Abstract:** An occultation of UCAC2 30429828 by the asteroid (611) Valeria on 2013 August 15 showed this star to be a double star with a separation of 380 mas

## Observation

On August 15, 2013, Chris Chad observed the asteroid (611) Valeria occult the star UCAC2 30429828 from Gunnedah, NSW, Australia. The observation was made with the equipment described in Table 1.

Video was analysed and light curves produced by the observer using Tangra V1.4 [3] software by Hristo Pavlov and results were analysed by Herald and Talbot using Occult4 [2] and Asteroidal Occultation Timing Analysis (AOTA) software by Dave Herald.

The star is of magnitude 12.01 (V), and has a corresponding expected apparent diameter of less than 0.1mas. The expected magnitude drop at occultation was 2.2 magnitudes with an expected maximum duration of 5 sec and 1 sigma error in central time of  $\pm 5$  sec.

The star is not listed in the Fourth Interferometric Catalogue, nor in the Washington Double Star catalog.

The light curve in Figure 1 obtained from the oc-

culation shows two clear separate dips of similar duration (3.5 sec and 4.1 sec), but with differing magnitude drop (1.5 mag and 0.5 mag) that were both lower than the predicted (2.2). This is characteristic of a double star event. The possibility of a binary asteroid was considered; however the different light drops in the two occultation events excludes that as an explanation.

The observations were analysed in the standard manner described by Herald [1]. The plot in Figure 2 below shows a probable solution along with the predicted path as a dotted line.

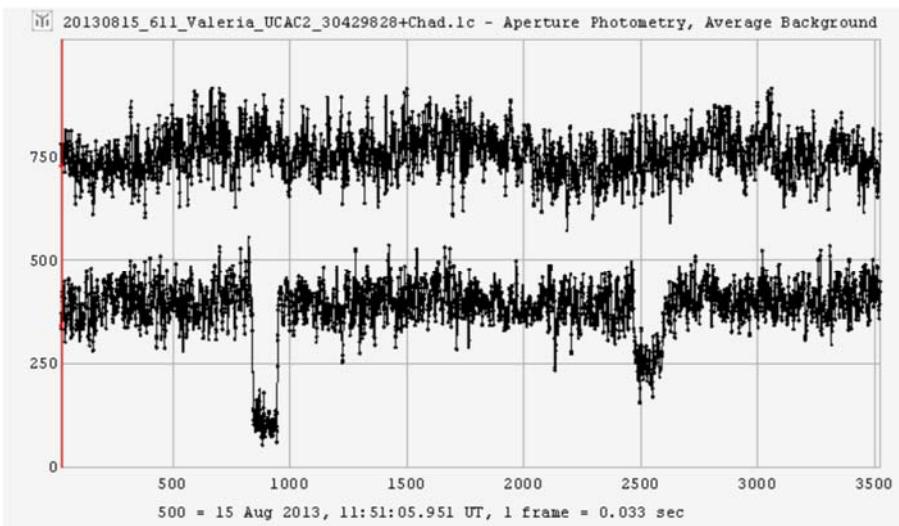
With only one chord for each star, there are four possible solutions which give rise to very small uncertainty in separation and a small uncertainty in PA. Figure 3 shows the two most extreme solutions, where the two stars are on opposite sides of the observed path. The resultant PA and Separation for the 4 solutions are shown in Table 2.

(Continued on page 31)

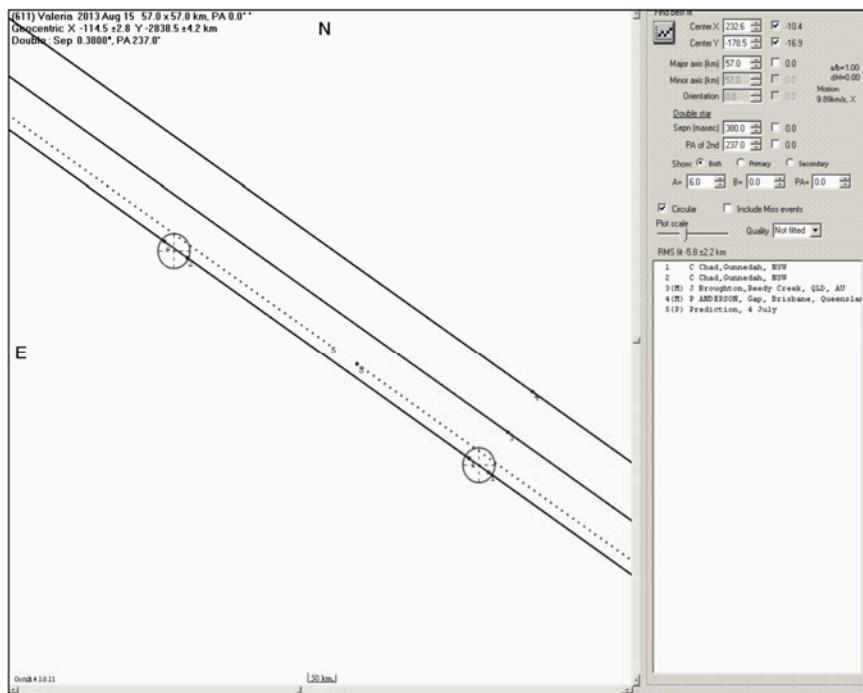
## A New Double Star from an Asteroidal Occultation: UCAC2 30429828

*Table 1: Observers and Equipment*

Observer	Telescope	Camera	Timing	Event
C. Chad, NSW,AU	25 cm	Samsung SCB-2000 Video	GPS time inserted	2 separate dips
J Broughton, QLD,AU	25 cm	Watec 120N+ video	GPS Time Inserted	Miss
P. Anderson, QLD,AU	41 cm	Visual	Radio Time	Miss



*Figure 1. Chris Chad's Light curve together with a comparison star from Tangra analysis.*



*Figure 2. Plot of result and predicted times.*

### A New Double Star from an Asteroidal Occultation: UCAC2 30429828

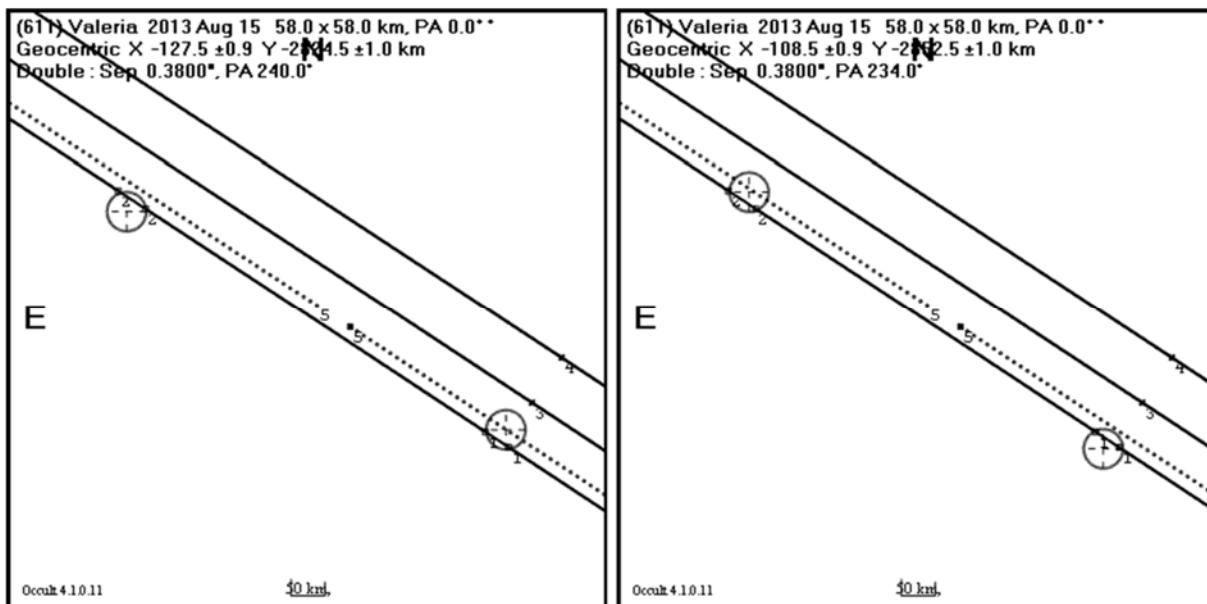


Figure 3. Plot showing offset shadows for the two stars with the two extreme possible solutions for the observation

Table 2. Four possible solutions for PA.

N	PA Deg	Separation mas
1	240	380
2	234	380
3	237	380
4	237	380

Examination of the star in Google Sky shows a very small distortion in the star shape compared to nearby stars of similar brightness. The star image is much larger than the measured separation. There are no obvious double diffraction spikes that sometimes indicate a double star.

The double star characteristics are:

Star	UCAC2 30429828 = UCAC4 429-099842 = GSC 5152-00921
Coordinates (J2000)	19h 33m 16.3s, -04° 17' 33.3"
Spectral type	(none found)
Mag A	12.44 ± 0.5 (V)
Mag B	13.36 ± 0.5 (V)
Separation	380 mas ± 1.0 mas
Position Angle	237° ± 3°
Epoch	2013.6210 (Besselian)

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3. Tangra Software by H. Pavlov <http://www.hristopavlov.net/Tangra/Tangra.html>

# Another Statistical Tool for Evaluating Binary Stars

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**Abstract:** Down through the years, astronomers have proposed many ways to estimate the number of binary and optical pairs in a given section of sky. In this paper, I propose a simple test to determine whether a given pair of stars is binary or optical based on the proper motions of the two stars. It will be shown that there is a very high correlation between binary status and common proper motion and optical status and different proper motions.

## Early Methods

Since the earliest days of binary star astronomy, astronomers have struggled to determine whether a pair they see in their telescopes is truly binary (that is, gravitationally bound to each other) or optical (a chance alignment of two stars that are very far apart in reality). Optical pairs may exhibit a linear change in relative position due to differences in proper motion, while binaries may show a non-linear / curved change due to orbital motion. (Of course, an optical pair whose components both have very small proper motions, if they are very distant, would not exhibit any significant motion, linear or otherwise, over a human lifetime or centuries or even millenia.) An early observer of double stars, John Michell, wrote (in 1767, see ref. 1) that the chance alignment theory of double stars was not adequate to account for all the double stars that astronomers could see in their telescopes. He strongly believed that many of the double stars he and his fellow astronomers observed were actually gravitationally bound. But the instrumentation of that time did not allow him (or anyone else) to verify his hypothesis.

The great English astronomer, William Herschel, arguably one of the greatest astronomers of all time, studied double stars to see if their (assumed) different distances would show different parallaxes and thus prove they were chance alignments. Of course, instrumentation of that day did not have the accuracy to reveal even the slightest parallax. This led Herschel to ponder the question of double stars actually being gravitationally bound. But in his research, he found more

double stars than he felt should be expected. A few years after his initial survey, he returned to the doubles he had discovered and found that many of them displayed a change in their measurements since his first observation. He concluded that most of the double stars astronomers could view in their telescopes were in fact gravitationally bound or true binaries.

In 1852, Wilhelm Friederich Struve [2] published a formula based on his empirical studies of double star distribution and measurements. This formula predicted how many optical pairs there would be in a piece of sky of area “A” where the total number of stars in “A” was known.

Other astronomers proposed statistical methods to identify possible binaries (Aitken [3], Couteau [4], et al).

In 1986, Jean-Louis Halbwachs wrote an article titled “Common Proper Motion Stars in the AGK3” [5]. Halbwachs set down three statistical criteria to identify potential binary stars given their proper motions and parallax.

All of these statistical approaches have merit. But in this paper I’m going to approach the problem from the other end — I am going to examine the physical properties of known binaries and suspected optical pairs, using the proper motions of both components of the system. I will show that by examining the proper motions of a given pair, we can obtain reasonable certainty that the pair is, in fact, a binary (or a linear).

## Methodology

I downloaded the most recent Washington Double Star Catalog and imported the records into an Excel

## Another Statistical Tool for Evaluating Binary Stars

spreadsheet. I then used Excel's filtering function to select pairs that had eight or more measurements. This returned 5,347 records. I copied those records to a new spreadsheet and began a long process of sending in batch requests to the Washington Double Star Catalog. It took me approximately a year to get the data from Brian Mason and William Hartkopf at the US Naval Observatory (due to the fact that I requested the data in small batch requests) and about 10 months to analyze the records. I ran the measurement histories through an Excel spreadsheet that I created to correct the data for precession and then plot the measurements on a graph. I found that 397 of the pairs I requested had orbital solutions already; 187 had linear solutions; 935 showed what appeared to be a part of an ellipse on the plot for the measurements; another 1,118 showed signs of linear motion; and 2,124 pairs showed no discernible pattern to their motions but did have common proper motion. (The plot of the data resembled the pattern of buckshot made by a shotgun at close range.) Thus only about 600 pairs in my survey could not be classified under either category because the proper motion of only one component is known.

I then turned my attention to the pairs with known orbital or linear solutions. All of the pairs in this group had proper motions of both components on record.

### The Statistical Sieve I Used

I was not surprised to see that almost all of the orbital solutions had common proper motions. Likewise almost all of the linear pairs had quite different proper motions. In only a few cases did an orbital solution involve two stars with very different proper motions, and only a few cases of linear solutions had identical proper motions. (This is especially attributable to the possibility that there were typographical errors in the original PM data.) Since the correlation to orbital and linear solutions was so strongly tied to the proper motions, I decided to create a sieve for this project based on a computation involving the proper motion vectors of each star.

It is customary to list the proper motion of a star with two numbers. The first number gives the annual displacement in right ascension in milli-arc seconds (MAS) per year with a positive number indicating motion to the east and a negative number motion to the west. Similarly, the declination number is positive when the star is moving northward and negative when it is moving southward. For example, the stars SAO 132119 and GSC 4753:1581 are a little over two minutes apart in the sky. They could be seen as a wide double star in even a modest telescope. However, the proper motions of these two stars are quite different. The SAO star has proper motion of [-15 +50] while the

GSC star has [+175 +134]. Thus, the SAO star is moving to the north northwest while the GSC star is moving to the northeast. Clearly, these two are not traveling through space together.

Since I had the proper motions for both stars for all the pairs in my sifted list, it was a simple step to subtract the proper motion vectors.

Using my SAO/GSC pair as an example, the difference would be [-15 +50] + [-175 -134] = [-190 -84].

But the difference in vectors is only part of the story. I also wanted to know how the difference compared to the sum of the two proper motion vectors. So I divided the difference in vectors by the sum of each vector's length to get a number (ranging from 0.00 to 0.99...). This let me "normalize" the calculations since a small difference with small proper motions would still give a rather large number (say, 0.68) while that same small difference with large proper motions would give a small number (say, 0.05).

Using my SAO/GSC pair, the difference between the PM vectors (-190, -84) gives rise to a scalar value of  $(190^2 + 84^2)^{1/2}$  or 207.74. The sum of the two PM vectors would be found by taking  $(15^2 + 50^2)^{1/2}$  or 52.20, plus  $(175^2 + 134^2)^{1/2}$  or 220.41, for a total of 272.6. Dividing the difference in the vectors by the sum of the vectors results in 207.74 / 272.6 or 0.8. I call this last result (0.8) the "rating" and its value will range from 0.00 for orbital pairs up to 0.99 for optical ones.

On the following pages, I present two tables: Table 1 contains the orbital pairs that I studied and Table 2 contains the linear pairs. In Table 1, note that with only a few exceptions, the ratings cluster around zero. In Table 2, notice how the ratings cluster near 100%. There are a few notable exceptions that I will discuss in

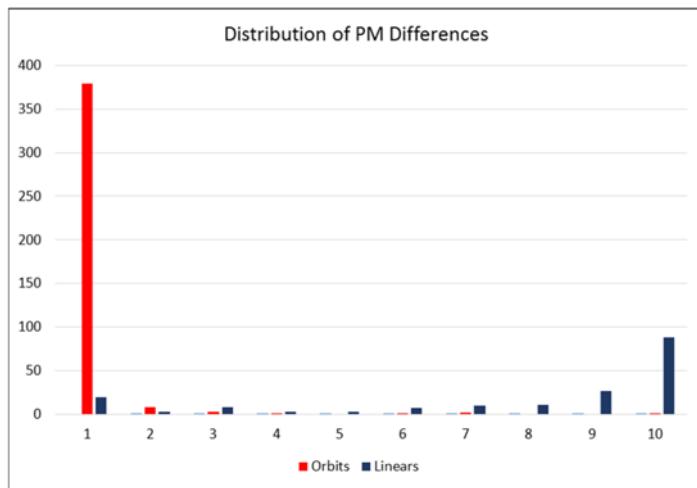


Figure 1: Distribution of proper motion differences .

(Continued on page 48)

**Another Statistical Tool for Evaluating Binary Stars***Table 1: Orbital Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
00003-4417	62	-107	62	-107	0.0	247.3	0.0
00014+3937	-30	-48	-30	-48	0.0	113.2	0.0
00048+3810	29	-60	29	-60	0.0	133.3	0.0
00057+4549 AB	879	-154	879	-154	0.0	1784.8	0.0
00063+5826	271	30	271	30	0.0	545.3	0.0
00093+7943	106	-33	106	-33	0.0	222.0	0.0
00098-3347	-62	-150	-62	-150	0.0	324.6	0.0
00162+7657	18	1	18	1	0.0	36.1	0.0
00167+3629	93	53	93	53	0.0	214.1	0.0
00184+4401 AB	2860	390	2884	410	31.2	5799.5	0.5
00206+1219	-27	7	-27	7	0.0	55.8	0.0
00210+6740	27	78	27	78	0.0	165.1	0.0
00214+6700 AB	25	0	25	0	0.0	50.0	0.0
00271-0753	-37	18	-37	18	0.0	82.3	0.0
00283+6344	63	3	63	3	0.0	126.1	0.0
00315-6257 CD	95	-49	95	-49	0.0	213.8	0.0
00321+6715 AB	172	-24	172	-32	8.0	348.6	2.3
00345-0433 AB	85	5	85	5	0.0	170.3	0.0
00360+2959 AB	191	-403	177	-388	20.5	872.4	2.4
00373-2446	1396	-14	1400	-10	5.7	2796.1	0.2
00424+0410 AB	27	-38	27	-38	0.0	93.2	0.0
00491+5749 AB	1141	-572	1105	-493	86.8	2486.3	3.5
00504+5038 AB	-36	-7	-36	-7	0.0	73.3	0.0
00521+1036	43	-33	43	-33	0.0	108.4	0.0
00521-1314	77	-93	77	-93	0.0	241.5	0.0
00546+1911 AB	15	-12	15	-12	0.0	38.4	0.0
00550+2338 AB	136	-30	136	-30	0.0	278.5	0.0
00583+2124	-13	-1	-13	-1	0.0	26.1	0.0
01030+4723	81	-12	81	-12	0.0	163.8	0.0
01055+2107	-13	-34	-13	-34	0.0	72.8	0.0
01095+4715 AB	0	-11	0	-11	0.0	22.0	0.0
01106+5101 Aa, Ab	1	21	1	21	0.0	42.	0.0
01148+6056	64	-44	64	-44	0.0	155.3	0.0
01158-6853 AB	405	108	383	87	30.4	811.9	3.7
01200-1549	53	-107	53	-107	0.0	238.8	0.0
01213+1132 AB	60	1	60	1	0.0	120.0	0.0
01337-1213	-11	-9	-11	-9	0.0	28.4	0.0
01361-2954	105	38	105	38	0.0	223.3	0.0
01388-1758	339	56	330	56	9.0	678.3	1.3
01424-0645	-32	-46	-32	-46	0.0	112.1	0.0

1. The magnitude of the difference vector in MAS

*Table continues on next page.*

**Another Statistical Tool for Evaluating Binary Stars***Table 1 (cont.) : Orbital Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
01437+0934	-45	-42	-45	-42	0.0	123.1	0.0
01456-2503 AB	162	-57	160	-72	15.1	347.2	4.4
01467+3310 AB	-26	-21	-26	-21	0.0	66.8	0.0
01499+8053	-17	1	-17	1	0.0	34.1	0.0
01551+2847 AB	28	-35	28	-35	0.0	89.6	0.0
01559+0151	164	189	164	189	0.0	500.5	0.0
02020+0246 AB	42	-11	42	-11	0.0	86.8	0.0
02022+3643 A, BC	147	-54	139	-56	8.2	306.5	2.7
02037+2556 AB	134	10	134	10	0.0	268.7	0.0
02140+4729	-77	-53	-77	-53	0.0	187.0	0.0
02158-1814	-52	-135	-52	-135	0.0	289.3	0.0
02159+0638	-111	-56	-111	-56	0.0	248.7	0.0
02174+6121 AB	51	-87	51	-87	0.0	201.7	0.0
02202+2949	-11	-14	-11	-14	0.0	35.6	0.0
02232-2952	-84	-104	-84	-104	0.0	267.4	0.0
02257+6133	17	-13	17	-13	0.0	42.8	0.0
02291+6724 AB	-18	12	-18	12	0.0	43.3	0.0
02407+2637	83	1	83	1	0.0	166.0	0.0
02460-0457	50	2	50	2	0.0	100.1	0.0
02475+1922 AB	115	-159	129	-169	17.2	408.8	4.2
02572-2458 AB	32	-35	32	-35	0.0	94.8	0.0
02589+2137	44	-19	44	-19	0.0	95.9	0.0
03124-4425 AB	92	-6	92	-6	0.0	184.4	0.0
03127+7133	15	16	15	16	0.0	43.9	0.0
03140+0044	76	-14	76	-14	0.0	154.6	0.0
03162+5810	446	-340	436	-305	36.4	1092.9	3.3
03175+6540 AB	-9	5	-9	5	0.0	20.6	0.0
03177+3838	112	-44	112	-44	0.0	240.7	0.0
03184-0056 AB	254	-62	254	-62	0.0	522.9	0.0
03217+0845	-27	-98	-27	-98	0.0	203.3	0.0
03350+6002	-25	28	-25	28	0.0	75.1	0.0
03362+4220	143	-146	143	-146	0.0	408.7	0.0
03463+2411 AB	18	-41	18	-41	0.0	89.6	0.0
03489+6445	21	-60	21	-60	0.0	127.1	0.0
03590+0947	95	-50	95	-50	0.0	214.7	0.0
04021-3429 AB	374	-12	374	-12	0.0	748.4	0.0
04041+3931	142	-98	142	-98	0.0	345.1	0.0
04064+4325	-28	-195	-28	-195	0.0	394.0	0.0
04076+3804 AB	174	-231	174	-231	0.0	578.4	0.0
04100+8042	-15	1	-15	1	0.0	30.1	0.0
04159+3142 AB	8	-51	8	-51	0.0	103.2	0.0

1. The magnitude of the difference vector in MAS

*Table continues on next page.*

**Another Statistical Tool for Evaluating Binary Stars***Table 1 (cont.) : Orbital Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
04170+1941	1	-101	1	-101	0.0	202.0	0.0
04179+5847	-17	-5	-17	-5	0.0	35.4	0.0
04182+2248	-5	-27	-5	-27	0.0	54.9	0.0
04215-2544 AB	48	-53	48	-53	0.0	143.0	0.0
04227+1503 AB	114	-26	114	-26	0.0	233.9	0.0
04233+1123	25	-38	25	-38	0.0	91.0	0.0
04269-2405	-9	-19	-9	-19	0.0	42.0	0.0
04290+1610	105	-25	105	-25	0.0	215.9	0.0
04301+1538	111	-28	111	-28	0.0	229.0	0.0
04366+1946	-8	-2	-8	-2	0.0	16.5	0.0
04367+1930	35	-39	35	-39	0.0	104.8	0.0
04382-1418	-76	-167	-76	-167	0.0	367.0	0.0
04422+3731	47	2	47	2	0.0	94.1	0.0
04518+1339 AB	90	-17	90	-17	0.0	183.2	0.0
04590-1623 AB	-132	136	-132	136	0.0	379.1	0.0
05005+0506	35	-38	35	-38	0.0	103.3	0.0
05017+2050	-67	-90	-67	-90	0.0	224.4	0.0
05047+7404	9	-17	9	-17	0.0	38.5	0.0
05055+1948	-10	-14	-10	-14	0.0	34.4	0.0
05079+0830	22	-61	22	-61	0.0	129.7	0.0
05098+2802 BC	103	16	26	-18	84.2	135.9	62.0
05135+0158 AB	7	2	7	2	0.0	14.6	0.0
05239-0052 BC	-5	-9	-5	-9	0.0	20.6	0.0
05247+6323	-121	-51	-121	-51	0.0	262.6	0.0
05308+0557	5	-42	5	-42	0.0	84.6	0.0
05320-0018 Aa, Ab	2	1	2	1	0.0	4.5	0.0
05364+2200	-35	-77	-41	-87	11.7	180.8	6.5
05371+2655 AB	7	-24	7	-24	0.0	50.0	0.0
05386+3030 AB	-21	-12	-21	-12	0.0	48.4	0.0
05407-0157	4	3	4	3	0.0	10.0	0.0
05474+2939	-15	-122	-15	-122	0.0	245.8	0.0
05589+1248	-12	3	-12	3	0.0	24.7	0.0
06003-3102 AC	-47	41	-44	102	61.1	173.5	35.2
06024+0939 AB	12	-34	12	-34	0.0	72.1	0.0
06048-4828	-106	-27	-106	-27	0.0	218.8	0.0
06298-5014 AB	-65	-52	-65	-52	0.0	166.5	0.0
06298-5014 CD	-68	-52	-68	-52	0.0	171.2	0.0
06344+1445	14	4	14	4	0.0	29.1	0.0
06364+2717	7	-98	7	-98	0.0	196.5	0.0
06462+5927 AB	-26	-17	-26	-17	0.0	62.1	0.0

1. The magnitude of the difference vector in MAS

*Table continues on next page.*

**Another Statistical Tool for Evaluating Binary Stars***Table 1 (cont.) : Orbital Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
06474+1812	5	-39	5	-39	0.0	78.6	0.0
06478+0020	-1	3	-1	3	0.0	6.3	0.0
06546+1311 AB	71	-80	70	-78	2.2	211.8	1.1
06555+3010	224	-239	224	-239	0.0	655.1	0.0
07128+2713 AB	14	-101	14	-101	0.0	203.9	0.0
07176+0918	-16	-114	-16	-114	0.0	230.2	0.0
07294-1500 AB	-188	-237	-188	-237	0.0	605.0	0.0
07303+4959	-11	-47	-11	-47	0.0	96.5	0.0
07346+3153 AB	-206	-148	-206	-148	0.0	507.3	0.0
07366-1429 AB	2	2	-32	-24	42.8	42.8	99.9
07417+0942	-11	-30	-11	-30	0.0	63.9	0.0
07461+2107	33	-7	33	-7	0.0	67.5	0.0
07518-1354	-60	-339	-60	-339	0.0	688.5	0.0
07546-0248	-22	-5	-22	-5	0.0	45.1	0.0
08024+0409	65	-105	65	-105	0.0	247.0	0.0
08041+3302	-13	7	-13	7	0.0	29.5	0.0
08044+1217 AB	101	-138	101	-138	0.0	342.0	0.0
08061-0047	87	-64	87	-64	0.0	216.0	0.0
08095+3213 AB	33	-8	33	-8	0.0	67.9	0.0
08122+1739 AB	80	-129	80	-129	0.0	303.6	0.0
08122+1739 AB, C	80	-129	86	-91	38.5	277.0	13.8
08122+1739 BC	80	-129	86	-91	38.5	277.0	13.9
08213-0136	-9	-28	-9	-28	0.0	58.8	0.0
08267+2432 BC	-37	-80	-37	-80	0.0	176.3	0.0
08331-2436 AB	-4	-31	-4	-31	0.0	62.5	0.0
08391-2240 AB	-261	430	-261	430	0.0	1006.0	0.0
08468+0625 AB, C	-194	-54	-262	14	96.2	463.7	20.7
08531+5457	38	42	38	42	0.0	113.3	0.0
08549+2612 AB	54	-441	54	-441	0.0	888.6	0.0
08554+7048 AB	-133	-36	-136	-41	5.8	279.8	2.1
08568-1726	-47	-2	-52	-28	26.5	106.1	25.0
09013+1516	-124	-314	-111	-320	14.3	676.3	2.1
09104+6708 AB	7	-95	4	-30	65.1	125.5	51.8
09144+5241 AB	-156	-57	-156	-66	9.0	335.5	2.7
09186+2049	-4	-50	-4	-50	0.0	100.3	0.0
09210+3811	-20	-23	-20	-23	0.0	61.0	0.0
09273+0614	-178	-151	-178	-151	0.0	466.8	0.0
09278-0604	-227	-77	-227	-77	0.0	479.4	0.0
09285+0903	50	-5	50	-5	0.0	100.5	0.0
09307-4028	-191	73	-191	73	0.0	408.9	0.0

1. The magnitude of the difference vector in MAS

*Table continues on next page.*

**Another Statistical Tool for Evaluating Binary Stars***Table 1 (cont.) : Orbital Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
09512+3629 AB	-98	-20	-98	-20	0.0	200.0	0.0
09525-0806	-57	-42	-57	-42	0.0	141.6	0.0
09551-2632	-149	-42	-149	-42	0.0	309.6	0.0
10043-2823	-41	-23	-41	-23	0.0	94.0	0.0
10062-4722	-1	-63	-1	-63	0.0	126.0	0.0
10131+2725	-50	-123	-50	-123	0.0	265.5	0.0
10163+1744	-7	1	-7	1	0.0	14.1	0.0
10192+2034	-164	-20	-164	-20	0.0	330.4	0.0
10200+1950 AB	311	-153	306	-161	9.4	692.4	1.4
10227+1521	-251	-101	-262	-86	18.6	546.3	3.4
10250+2437	12	-194	12	-194	0.0	388.7	0.0
10269+1713	-42	-67	-42	-67	0.0	158.2	0.0
10275+0334	-131	-22	-131	-22	0.0	265.7	0.0
10292+1009	-3	-30	-3	-30	0.0	60.3	0.0
10361-2641	-8	-86	-8	-86	0.0	172.7	0.0
10397+0851	-105	6	-105	6	0.0	210.3	0.0
10480+4107	-21	-3	-21	-3	0.0	42.4	0.0
10525-1838	-71	27	-71	27	0.0	151.9	0.0
10596+2527	-184	-50	-178	-82	32.6	386.7	8.4
11035+5432	-126	77	-126	77	0.0	295.3	0.0
11047-0413 BC	-178	-104	-178	-104	0.0	412.3	0.0
11125-1830	-21	-27	-21	-27	0.0	68.4	0.0
11137+2008 AB	-388	-125	-388	-125	0.0	815.3	0.0
11152+7329 AC	-402	110	-404	112	2.8	836.0	0.3
11182+3132 AB	-454	-591	-454	-591	0.0	1490.5	0.0
11190+1416	54	-161	54	-161	0.0	339.6	0.0
11210-5429	-40	-3	-40	-3	0.0	80.2	0.0
11239+1032 AB	153	-65	153	-65	0.0	332.5	0.0
11247-6139	-491	99	-562	77	74.3	1068.1	7.0
11272-1539	2	-197	2	-197	0.0	394.0	0.0
11308+4117	92	-98	92	-98	0.0	268.8	0.0
11363+2747 AB	27	13	27	13	0.0	59.9	0.0
11368-1221	7	-46	7	-46	0.0	93.1	0.0
11387+4507 AB	-594	15	-577	2	21.4	1171.2	1.8
11390+4109 AB	-81	-38	-81	-38	0.0	178.9	0.0
11486+1417	-102	4	-102	4	0.0	204.2	0.0
12018-3439	-191	17	-191	17	0.0	383.5	0.0
12036-3901	-383	-39	-383	-39	0.0	770.0	0.0
12158-2321	-9	-39	-9	-39	0.0	80.1	0.0
12160+0538	-320	-66	-320	-66	0.0	653.5	0.0

1. The magnitude of the difference vector in MAS

*Table continues on next page.*

**Another Statistical Tool for Evaluating Binary Stars***Table 1 (cont.) : Orbital Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
12244+2535 AB	-13	-13	-13	-13	0.0	36.8	0.0
12266-6306 AB	-35	-15	-43	-8	10.6	81.8	13.0
12272+2701	81	-248	81	-248	0.0	521.8	0.0
12301-1324 AB	-251	-47	-238	-32	19.8	495.5	4.0
12306+0943	51	-58	51	-58	0.0	154.5	0.0
12396-3717	-262	-268	-262	-268	0.0	749.6	0.0
12415-4858 AB	-194	-12	-194	-12	0.0	388.7	0.0
12422+2622	2	80	2	80	0.0	160.1	0.0
12533+2115 AB	-48	-27	-48	-27	0.0	110.1	0.0
12567-4741	-60	-3	-60	-3	0.0	120.1	0.0
13038-2035	134	1	134	1	0.0	268.0	0.0
13100+1732 AB	-430	138	-430	138	0.0	903.2	0.0
13169+1701 AB	624	-259	631	-261	7.3	1358.5	0.5
13235+2914	-468	245	-468	245	0.0	1056.5	0.0
13237-0043	-53	-23	-53	-23	0.0	115.6	0.0
13258+4430 AB	22	-8	22	-8	0.0	46.8	0.0
13284+1543	-57	13	-57	13	0.0	116.9	0.0
13328+1649	270	-226	270	-226	0.0	704.2	0.0
13336+2944	-52	66	-52	66	0.0	168.0	0.0
13343-0019 AB	-219	21	-219	21	0.0	440.0	0.0
13372-6142 AB	154	-111	154	-111	0.0	379.7	0.0
13375+3618 AB	-104	28	-85	2	32.2	192.7	16.7
13461+0507	-103	-35	-103	-35	0.0	217.6	0.0
13491+2659	-427	-90	-436	-111	22.8	886.3	2.6
13520-3137	-38	-45	-38	-45	0.0	117.8	0.0
13535-3540 AB	-86	-21	-86	-21	0.0	177.1	0.0
13550-0804	-175	-34	-166	-50	18.4	351.6	5.2
13577+5200	236	-7	236	-7	0.0	472.2	0.0
14020+5713 AB	-8	-11	-8	-11	0.0	27.2	0.0
14131+5520	-345	-12	-345	-12	0.0	690.4	0.0
14135+5147	61	-11	65	-4	8.1	127.1	6.3
14153+0308	-198	50	-198	50	0.0	408.4	0.0
14160-0704	108	-19	108	-19	0.0	219.3	0.0
14195-1343	-174	-47	-190	-45	16.1	375.5	4.3
14203+4830	-73	-14	-73	-14	0.0	148.7	0.0
14234+0827 BC	-75	-10	-75	-10	0.0	151.3	0.0
14369+4813	-17	46	-17	46	0.0	98.1	0.0
14411+1344 AB	66	-21	66	-21	0.0	138.5	0.0
14428+0635 AB	-164	64	-164	64	0.0	352.1	0.0
14455+4223 AB	-67	54	-67	54	0.0	172.1	0.0

1. The magnitude of the difference vector in MAS

*Table continues on next page.*

**Another Statistical Tool for Evaluating Binary Stars***Table 1 (cont.) : Orbital Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
14463+0939 AB	71	-266	71	-266	0.0	550.6	0.0
14464-0723 AB	-150	103	-150	103	0.0	363.9	0.0
14489+0557	-8	-89	-8	-89	0.0	178.7	0.0
14514+1906 AB	159	-136	90	-147	69.9	381.6	18.3
14515+4456	-13	-39	-13	-39	0.0	82.2	0.0
14534+1542	-20	30	-20	30	0.0	72.1	0.0
14542-6625	-280	-178	-280	-178	0.0	663.6	0.0
14575-2125 AB	104	-173	99	-166	8.6	395.1	2.2
14575-2125 BC	99	-167	106	-167	7.0	391.9	1.8
14587-2739	-44	-11	-44	-11	0.0	90.7	0.0
15038+4739	-444	10	-374	39	75.8	820.1	9.2
15160-0454 AB	23	-29	23	-29	0.0	74.0	0.0
15183+2650 AB	88	77	88	77	0.0	233.9	0.0
15245+3723 Ba, Bb	-151	87	-151	87	0.0	348.5	0.0
15348+1032 AB	-72	13	-73	3	10.0	146.2	6.9
15351-4110	-28	-42	-28	-42	0.0	101.0	0.0
15360+3948 AB	-455	51	-455	51	0.0	915.7	0.0
15382+3615 AB	-62	43	-60	35	8.2	144.9	5.7
15382+3615 CD	-62	43	-62	43	0.0	150.9	0.0
15396+7959	-33	39	-33	39	0.0	102.2	0.0
15413+5959	-220	165	-220	165	0.0	550.0	0.0
15427+2618	-107	48	-107	48	0.0	234.5	0.0
16035-5747 AB	-157	-95	-157	-95	0.0	367.0	0.0
16044-1122 AB	-72	-35	-72	-35	0.0	160.1	0.0
16044-1122 AC	-72	-35	-75	-28	7.6	160.1	4.8
16085-1006	36	-110	36	-110	0.0	231.5	0.0
16147+3352 AB	-265	-84	-289	-85	24.0	579.2	4.1
16289+1825 AB	-340	383	-340	383	0.0	1024.3	0.0
16309+0159 AB	-21	-88	-21	-88	0.0	180.9	0.0
16413+3006	-43	92	-43	92	0.0	203.1	0.0
16439+4329	-75	-51	-75	-51	0.0	181.4	0.0
16492+4559 A, BC	22	-56	23	-51	5.1	116.1	4.4
16511+0924 AB	16	-122	16	-122	0.0	246.1	0.0
16518+2840 AB	-6	36	-6	36	0.0	73.0	0.0
16564+6502 AB	-33	34	-33	34	0.0	94.8	0.0
17053+5428 AB	-68	89	-68	89	0.0	224.0	0.0
17066+0039	-21	-10	-21	-10	0.0	46.5	0.0
17082-0105	-14	-41	-14	-41	0.0	86.6	0.0
17141+5608	-17	15	-17	15	0.0	45.3	0.0
17146+1423 AB	-17	47	-7	33	17.2	83.7	20.6

1. The magnitude of the difference vector in MAS

*Table continues on next page.*

**Another Statistical Tool for Evaluating Binary Stars***Table 1 (cont.) : Orbital Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
17157-0949 AB	12	-21	12	-21	0.0	48.4	0.0
17166-0027	-31	-73	-31	-73	0.0	158.6	0.0
17191-4638 AB	105	14	97	14	8.0	203.9	3.9
17248+3044	-2	5	-2	5	0.0	10.8	0.0
17293+2924 AB	-189	-278	-189	-278	0.0	672.3	0.0
17304-0104	-127	-180	-127	-180	0.0	440.6	0.0
17350+6153 AB	265	-521	277	-526	13.0	1179.0	1.1
17386+5546	4	-12	4	-12	0.0	25.3	0.0
17457+1743	-25	74	-25	74	0.0	156.2	0.0
17471+1742	12	-13	12	-13	0.0	35.4	0.0
17506+0714	12	19	12	19	0.0	44.9	0.0
17530+8354	5	8	5	8	0.0	18.9	0.0
17533+2459	-70	-50	-70	-50	0.0	172.0	0.0
17571+0004	26	-9	26	-9	0.0	55.0	0.0
18025+4414 AB	-40	-67	-40	-67	0.0	156.1	0.0
18031-0811 AB	9	-48	9	-48	0.0	97.7	0.0
18055+0230 AB	28	-109	44	-125	22.6	245.1	9.2
18058+2127 AB	-29	-40	-29	-40	0.0	98.8	0.0
18063+3824	-17	-10	-17	-10	0.0	39.4	0.0
18068-4325	14	-105	14	-105	0.0	211.9	0.0
18068-4325	14	-105	14	-105	0.0	211.9	0.0
18096+0400 AB	46	-7	46	-7	0.0	93.1	0.0
18097+5024	7	7	7	7	0.0	19.8	0.0
18146+0011	20	-35	20	-35	0.0	80.6	0.0
18250+2724 AB	3	-12	3	-12	0.0	24.7	0.0
18250-0135	5	-6	5	-6	0.0	15.6	0.0
18355+2336	5	3	5	3	0.0	11.7	0.0
18359+1659 AB	49	-71	50	-67	4.1	169.9	2.4
18360+1144	12	-11	12	-11	0.0	32.6	0.0
18428+5938 AB	-133	181	-141	184	8.5	456.4	1.9
18437+3141	-43	-41	-43	-41	0.0	118.8	0.0
18443+3940 AB	11	61	2	47	16.6	109.0	15.3
18443+3940 CD	8	54	8	54	0.0	109.2	0.0
18537-0533	-24	-33	-24	-33	0.0	81.6	0.0
18575+5814	4	37	39	2	49.5	76.3	64.9
19027-0043 BC	37	-9	37	-9	0.0	76.2	0.0
19043-2132	69	-41	69	-41	0.0	160.5	0.0
19055+3352	17	-31	17	-31	0.0	70.7	0.0
19062+3026 AB	64	-5	64	-5	0.0	128.4	0.0
19064-3704	88	-284	88	-284	0.0	594.6	0.0

1. The magnitude of the difference vector in MAS

*Table continues on next page.*

**Another Statistical Tool for Evaluating Binary Stars***Table 1 (cont.) : Orbital Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
19121+4951 AB	-210	622	-184	629	26.9	1311.9	2.1
19143+1904	32	-27	32	-27	0.0	83.7	0.0
19266+2719	97	88	97	88	0.0	261.9	0.0
19296-1239	104	-36	104	-36	0.0	220.1	0.0
19316+1747	-7	-120	5	-116	12.6	236.3	5.4
19394+2215	3	13	3	13	0.0	26.7	0.0
19406+6240	26	111	26	111	0.0	228.0	0.0
19418+5032 AB	-148	-159	-132	-163	16.5	427.0	3.9
19464+3344 FG	19	-446	19	-446	0.0	892.8	0.0
19487+3519	74	63	74	63	0.0	194.4	0.0
19520-1021 AB	-14	-49	-14	-49	0.0	101.9	0.0
19580+0456	26	3	26	3	0.0	52.3	0.0
20012-3835	18	-70	18	-70	0.0	144.6	0.0
20014+1045 AB	83	25	82	54	29.0	184.9	15.7
20102+4357	9	89	9	89	0.0	178.9	0.0
20176+2622	-8	-78	-8	-78	0.0	156.8	0.0
20182+2912	-6	-87	-6	-87	0.0	174.4	0.0
20198+4522	18	-29	18	-29	0.0	68.3	0.0
20289-1749 AB	-3	-17	-3	-17	0.0	34.5	0.0
20312+1116 BC	-6	-10	-6	-10	0.0	23.3	0.0
20393-1457 AB	2	-21	2	-21	0.0	42.2	0.0
20396+4035 AB	0	-4	0	-4	0.0	8.0	0.0
20407+4321	147	70	145	68	2.8	323.0	0.9
20450+1244 AB	-11	-4	-11	-4	0.0	23.4	0.0
20462+1554 AB	95	67	100	75	9.4	241.2	3.9
20467+1607	-31	-198	-1	-204	30.6	404.4	7.6
20494+1124 AB	196	-132	196	-132	0.0	472.6	0.0
20519+0544	75	-4	75	-4	0.0	150.2	0.0
20550+2805 AB	109	-81	109	-81	0.0	271.6	0.0
20591+0418 AB	-102	-152	-102	-152	0.0	366.1	0.0
21031+0132 AB	-107	-53	-107	-53	0.0	238.8	0.0
21069+3845 AB	416	326	412	313	13.6	1045.9	1.3
21148+3803 AB	159	431	159	431	0.0	918.8	0.0
21208+3227 AB	53	-45	53	-45	0.0	139.1	0.0
21223+5734 AB	74	26	77	28	3.6	160.4	2.2
21289+1105	71	14	71	14	0.0	144.7	0.0
21395-0003 AB	228	15	228	15	0.0	457.0	0.0
21410+2920	73	-14	73	-14	0.0	148.7	0.0
21426+4103 AB	26	-1	26	-1	0.0	52.0	0.0
21441+2845 AB	277	-251	277	-251	0.0	747.6	0.0

1. The magnitude of the difference vector in MAS

*Table concludes on next page.*

**Another Statistical Tool for Evaluating Binary Stars***Table 1 (conc.) : Orbital Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
21555+1053 AB	-85	-120	-85	-120	0.0	294.1	0.0
21582+8252 AB	-133	-47	-137	-40	8.1	283.8	2.8
22038+6438 AB	208	89	202	86	6.7	445.8	1.5
22086+5917 BC	10	1	10	1	0.0	20.1	0.0
22100+2308	-19	-8	-19	-8	0.0	41.2	0.0
22202+2931	78	18	78	18	0.0	160.1	0.0
22266-1645 AB	251	-21	251	-21	0.0	503.8	0.0
22280+5742 AB	-802	-386	-713	-321	110.2	1672.0	6.6
22300+0426	-31	-146	-31	-146	0.0	298.5	0.0
22302+2228	22	-22	22	-22	0.0	62.2	0.0
22330+6955	117	66	117	66	0.0	268.7	0.0
22400+0113	66	60	66	60	0.0	178.4	0.0
22408-0333	-3	-48	-3	-48	0.0	96.2	0.0
22409+1433 AB	274	137	274	137	0.0	612.7	0.0
22419+2126	64	-69	64	-69	0.0	188.2	0.0
22431+4710 BC	-1	-2	-1	-2	0.0	4.5	0.0
22455+1112 AB	14	-173	14	-163	10.0	337.2	3.0
22478-0414 AB	-200	-313	-200	-313	0.0	742.9	0.0
22514+2623 AB	-4	9	-4	9	0.0	19.7	0.0
22537+4445 AB	-3	-17	-3	-17	0.0	34.5	0.0
22557+1547	122	25	122	25	0.0	249.1	0.0
22592+1144	32	-41	32	-41	0.0	104.0	0.0
23026+4245 AB	59	-6	59	-6	0.0	118.6	0.0
23079+7523 AB	6	-31	6	-31	0.0	63.2	0.0
23103+3229 AB	15	-4	15	-4	0.0	31.0	0.0
23176-0131 AB	255	-93	255	-93	0.0	542.9	0.0
23186+6807 AB	53	24	46	13	13.0	106.0	12.3
23280+3333	-22	-17	-22	-17	0.0	55.6	0.0
23340+3120	49	-17	49	-17	0.0	103.7	0.0
23375+4426 AB	14	-13	14	-13	0.0	38.2	0.0
23431+1150	102	-2	102	-2	0.0	204.0	0.0
23440+2922	71	-39	71	-39	0.0	162.0	0.0
23487+6453 AB	21	-14	21	-14	0.0	50.5	0.0
23506-5142	71	-100	71	-100	0.0	245.3	0.0
23516+4205 AB	-1	-8	-1	-8	0.0	16.1	0.0
23595+3343 AB	-47	-97	-63	-92	16.8	219.3	7.6

1. The magnitude of the difference vector in MAS

**Another Statistical Tool for Evaluating Binary Stars***Table 2: Linear Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
00028+0208	62	-94	54	-92	8.2	219.3	3.8
00047+3416 AB, C	-17	-27	123	-60	143.8	168.8	85.2
00057+4549 AD	879	-154	3	0	889.4	895.4	99.3
00059+1805 AC	-146	-146	-2	-17	193.3	223.6	86.5
00066+2901 AB	381	-178	5	-13	410.6	434.5	94.5
00159+5233 AB	56	-45	30	-7	46.0	102.6	44.9
00175+0019 AB	20	107	-32	-9	127.1	142.1	89.5
00184+4401 AC	2860	390	-33	-19	2921.8	2924.5	99.9
00187+2545 AB	-3	0	-17	-38	40.5	44.6	90.7
00201+4232	29	31	-15	-3	55.6	57.7	96.3
00224+1329	62	21	-8	-24	83.2	90.8	91.7
00272+4959 AB	5	-4	53	-4	48.0	59.6	80.6
00277-1625 AB	208	33	-76	-142	333.6	371.7	89.8
00282-6555 AC	-11	-6	87	-5	98.0	99.7	98.3
00296-2311	9	-8	-3	5	17.7	17.9	99.0
00305+2208	65	10	-11	-17	80.7	86.0	93.8
00308+1602	-29	-3	42	-26	74.6	78.6	95.0
00360+2959 AC	191	-403	-3	-60	394.1	506.0	77.9
00384+4059	22	-15	-9	-3	33.2	36.1	92.0
00387+4657 AB	-49	3	16	8	65.2	67.0	97.3
00396+8445 AB	50	21	77	-24	52.5	134.9	38.9
00408-0714	9	-102	1	-92	12.8	194.4	6.6
00434-0054 AB	-116	-224	5	6	259.9	260.1	99.9
00444+7713	-9	20	25	-14	48.1	50.6	95.1
00458-4155	307	-76	288	-111	39.8	624.9	6.4
00464+3057	-20	-64	-41	-28	41.7	116.7	35.7
00491+5749 AE	114	-57	-3	-1	129.7	130.6	99.3
00496-5410	68	-1	15	-11	53.9	86.6	62.3
00498+7027	371	203	24	-3	403.5	447.1	90.3
00504+5038 AB, C	-36	-7	3	-3	39.2	40.9	95.8
00568+3830 AD	152	33	-13	12	166.3	173.2	96.0
00594+0047 AB	-26	-109	3	-8	105.1	120.6	87.1
00595+8341	18	-1	102	10	84.7	120.5	70.3
01044-0518 AB	-10	47	14	-29	79.7	80.3	99.3
01048-0528 AB	6	1	58	-1	52.0	64.1	81.2
01083+5455 AB	342	-160	-5	7	385.1	386.2	99.7
01207+4620 AB	-36	8	-9	-6	30.4	47.7	63.8
01211+6439	59	-25	-10	-13	70.0	80.5	87.0
01259+6808 AC	74	26	-2	8	78.1	86.7	90.1
01270-0009 AB	298	-358	-3	-6	463.1	472.5	98.0

*Table continues on next page.*

**Another Statistical Tool for Evaluating Binary Stars***Table 2 (cont.): Linear Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
01399+1515 AB	-2	-9	220	-63	228.5	238.1	96.0
01417-1119	43	-417	43	-417	0.0	838.4	0.0
01510+2107 AB	63	-28	92	79	110.9	190.2	58.3
02135-2546	70	-27	-15	-15	85.8	96.2	89.2
02442+4914 AB	511	-90	336	-84	175.1	865.2	20.2
02498-2015	20	11	38	-29	43.9	70.6	62.1
02556+2652 AB	274	-185	270	-168	17.5	648.6	2.7
02578+4431 AB	48	6	109	-18	65.6	158.8	41.3
03053+4254	60	-27	-3	1	68.9	69.0	100.0
03122+3713	-38	-39	-38	-39	0.0	108.9	0.0
03440+3822 AB	-1	-4	23	16	31.2	32.1	97.2
03463+2411 AB-C	18	-41	17	-8	33.0	63.6	51.9
04130-2832	90	44	90	44	0.0	200.4	0.0
04153-0739 AD	-226	-342	34	-42	397.0	464.0	85.6
04376-0228 AB	43	-64	1	20	93.9	97.1	96.7
04385+2656 AB	41	-56	41	-88	32.0	166.5	19.2
05100-0704	-60	-240	-3	-4	242.8	252.4	96.2
05119-0907	-72	-559	7	-8	556.6	574.2	96.9
05154+3241 AB	-24	11	25	-1	50.4	51.4	98.1
05167+4600 AF	76	-425	4	-3	428.1	436.7	98.0
05191+4006 AD	679	-665	0	-1	949.7	951.4	99.8
05191+4006 AE	679	-665	-2	1	952.5	952.6	100.0
05226+7914 AB	-79	161	55	-155	343.2	343.8	99.8
05341+6940	-10	78	12	4	77.2	91.3	84.6
05418+1933 AB	17	4	-5	-4	23.4	23.9	98.1
05561+1356 AB	374	-481	-52	11	650.8	662.4	98.2
05561+1356 AD	374	-481	19	-25	577.9	640.7	90.2
06422+5038 AC	-2	1	28	-145	149.1	149.9	99.4
06443+4037	-25	-157	193	38	292.5	355.7	82.2
07166-2319	-1	4	-31	42	48.4	56.3	86.0
07294-1500 AD	-188	-237	20	-12	306.4	325.8	94.0
07366-1429 AD	2	2	-7	3	9.1	10.4	86.7
08047+1204 AB	4	-1	-2	-34	33.5	38.2	87.8
08258+3104 AB	45	-80	5	-5	85.0	98.9	86.0
08358+0637 AE	-127	-129	23	-51	169.1	237.0	71.3
08452+4140 AB	-284	-652	-11	-9	698.6	725.4	96.3
09144+5241 AD	-156	-57	4	0	169.8	170.1	99.9
09157-0114 AB	-117	-73	-24	-16	109.1	166.8	65.4
09449-8031	47	54	-5	2	73.5	77.0	95.5
09522+0313	-426	17	-12	6	414.1	439.8	94.2

*Table continues on next page.*

**Another Statistical Tool for Evaluating Binary Stars***Table 2 (cont.): Linear Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
09573-2902	-22	10	1	-40	55.1	64.2	85.8
10015+6843	-44	-24	-46	-24	2	102.0	2.0
10029+6847	-27	-19	-31	-22	5	71.0	7.0
10041-7604	35	-3	-39	-3	74	74.3	99.7
10049+5529 AB	-5	0	55	-35	69.5	70.2	99.0
10200+1950 AC	311	-153	-502	-43	820.4	850.4	96.5
10200+1950 CD	-502	-43	-11	-25	491.3	531.2	92.5
11111+3027 AC	591	-198	-63	-16	678.9	688.3	98.6
11137+2008 AB, C	-388	-125	-21	1	388.0	428.7	90.5
11152+7329 AB	-402	110	1	-2	418.3	419.0	99.8
11279+0251 AB	17	-10	-90	17	110.4	111.3	99.1
11387+4507 AC	-594	15	0	4	594.1	598.2	99.3
11387+4507 AE	-594	15	-31	7	563.1	6256.0	89.9
12023+7222	24	3	-17	13	42.2	45.6	92.6
12095-1151 AB	296	-168	296	-168	0.0	680.7	0.0
12095-1151 AC	296	-168	1	-69	311.2	409.4	76.0
12095-1151 BC	296	-168	1	-69	311.2	409.4	76.0
12115+5325	-164	-125	-170	-136	12.5	423.9	3.0
12116+3605 AB	-46	7	55	-39	111.0	114.0	97.4
12151-0715 AB	-250	-53	-241	-69	18.4	506.2	3.6
12281+4448	-180	-7	-178	4	11.2	358.2	3.1
12351+0727 AC	155	-91	-41	8	219.6	221.5	99.1
12454+1422	-50	4	82	-45	140.8	143.7	98.0
12555+1130	-22	-8	-86	20	69.9	111.7	62.5
13064+7618	-58	15	-33	10	25.5	94.4	27.0
13120+3205	15	-6	15	-6	0.0	32.3	0.0
13518-3300	-70	-22	-36	-30	34.9	120.2	29.0
14497+4843	-78	97	-78	97	0.0	248.9	0.0
14584+7108 AC	-5	-13	-48	9	48.3	62.8	77.0
15090-2144	-43	7	17	-41	76.8	88.0	87.4
15169-0817 AB	-102	-237	-100	-225	12.2	504.2	2.4
15174+4348 AB	2	-26	-6	5	32.0	33.9	94.5
15261+1810	14	-8	14	-8	0.0	32.2	0.0
15598+1723 AB	8	2	-27	-66	76.5	79.6	96.1
16060+1319 AB	18	-19	-15	-3	36.7	41.5	88.4
16081+1703 AB	-34	-6	-26	-32	27.2	75.8	35.9
16147+3352 BD	-289	-85	4	-17	300.8	318.7	94.4
16256-2327 AB	35	-32	-14	-27	49.3	77.8	63.3
16278+2054 AC	34	-119	-36	36	170.1	174.7	97.4
17048+2805 AB	7	7	-97	-97	147.1	147.1	100.0

*Table continues on next page.*

**Another Statistical Tool for Evaluating Binary Stars***Table 2 (cont.): Linear Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
17121+2114 AB	22	4	-1	-8	25.9	30.4	85.3
17153-2636 AD	-57	-115	0	3	131.0	131.4	99.8
17153-2636 BD	-53	-114	0	3	128.4	128.7	99.8
17262+2927 AB	0	3	19	3	19.0	22.2	85.4
17293+2924 AB, C	-189	-278	-9	-10	322.8	349.6	92.3
17427-2222	-7	-66	5	-10	57.3	77.6	73.9
18029+5626 AC	-17	38	6	12	34.7	55.0	63.1
18055+0230 AC	28	-109	-2	-1	112.1	114.8	97.7
18055+0230 AD	28	-109	0	0	112.5	112.5	100.0
18055+0230 AS	28	-109	1	0	112.3	113.5	98.9
18222-1505 AB	23	28	7	14	21.3	51.9	41.0
18312+1311	1	-21	21	-1	28.3	42.0	67.3
18369+3846 AB	201	288	4	-6	353.9	358.4	98.7
18485+1045 AB	127	-437	5	6	459.5	462.9	99.3
18485+1045 AC	127	-437	-4	-10	446.6	465.9	95.9
18485+1045 AD	127	-437	4	4	457.8	460.7	99.4
18512+5923 AB	79	25	-16	20	95.1	108.5	87.7
18591+1338 AB	17	-126	9	-12	114.3	142.1	80.4
19037+1658	-20	-74	7	-10	69.5	88.9	78.2
19074+3230 AC	124	30	122	111	81.0	292.5	27.7
19074+3230 CE	122	111	0	-1	165.6	165.9	99.8
19121+4951 AD	-210	622	-29	-34	680.5	701.2	97.1
19201+2639 AB	13	-52	-19	11	70.7	75.6	93.5
19246+2131 AB	15	34	8	-72	106.2	109.6	96.9
19266+2530	16	-10	8	1	13.6	26.9	50.5
19314+3643 AC	7	-15	4	3	18.2	21.6	84.7
19368-1027	-271	-299	-300	-263	46.2	802.5	5.8
19524+2551 AC	4	11	27	24	26.4	47.8	55.2
20099+2055 AC	59	97	5	-5	115.4	120.6	95.7
20099+2055 BC	78	90	5	-5	119.8	126.2	95.0
20144-0603 AB	37	-1	48	16	20.2	87.6	23.1
20329+1357 AB, CD	19	-17	-77	148	190.9	192.3	99.3
20368+1444 AC	13	13	-19	-47	68.0	69.1	98.4
20368+1444 BC	12	12	-19	-47	66.6	67.7	98.5
20387+3838 AB	202	-195	24	-8	258.2	306.1	84.4
20494+1124 AB, C	196	-132	116	-105	84.4	392.8	21.5
20517-4054	16	-11	22	-11	6.0	44.0	13.6
20520+4346	7	-2	28	6	22.5	35.9	62.6
21124-1500	78	-40	50	-22	33.3	142.3	23.4
21144+2905 AB	-4	-17	32	2	40.7	49.5	82.2

*Table concludes on next page.*

## Another Statistical Tool for Evaluating Binary Stars

*Table 2 (conc.): Linear Solutions*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
21148+3803 AD	159	431	-1	-4	463.5	463.5	100.0
21330+2043 AB	-5	-43	-5	-25	18.0	68.8	26.2
21441+2845 AD	277	-251	-1	-55	340.1	428.8	79.3
21495+0324 AB	-4	-15	25	-57	51.0	77.8	65.6
21520+5548 AB	20	1	11	23	23.8	45.5	52.2
21555+5232 AC	-10	-4	81	11	92.2	92.5	99.7
21555+5232 CD	81	11	2	-1	79.9	84.0	95.1
22045+1551 AE	-25	-69	57	-64	82.2	159.1	51.6
22057+2954	-8	-15	-42	-31	37.6	69.2	54.3
22143+1711 AB	-81	-93	-83	-91	2.8	246.5	1.1
22237+2051 AC	335	-17	14	-13	321.0	354.5	90.5
22280+5742 AC	-802	-386	1	-1	890.5	891.5	99.9
22280+5742 AI	-802	-386	-8	-8	879.4	901.4	97.6
22326+0725	-17	-2	35	16	55.0	55.6	99.0
22396-1237 AB	228	-152	228	-165	13.0	555.5	2.3
22477-1403 AB	31	-10	-31	-18	62.5	68.4	91.4
22478-0414 BC	-200	-313	7	-5	371.1	380.0	97.6
22490+6834 AB	114	61	117	73	12.4	267.2	4.6
23077+0636 AC	55	1	-2	-13	58.7	68.2	86.1
23133+2205 AB	4	-50	9	-38	13.0	89.2	14.6
23141-0855 AC	556	-40	81	-39	475.0	647.3	73.4
23141-0855 BC	561	-34	81	-39	480.0	651.9	73.6
23212+3526 AB	-1	-2	24	-8	25.7	27.5	93.4
23228+2034 AC	313	-12	5	-7	308.0	321.8	95.7
23564-0930 AB	-266	-66	-287	-60	21.8	567.3	3.9

(Continued from page 33)

a moment.

I then programmed Excel to generate a histogram of all of the data, which is shown in Figure 1.

As you can see in Figure 1, orbital solutions show very small “ratings” (near 0.0) while optical pairs showed high values (near 100.0)

Orbits are graded as to their accuracy or reliability (with 1 being a strong solution and 5 classed as indeterminate). Linear solutions are not graded. This partly explains the much wider spread of the linear solution data.

But there's another force at work, too. Linear solutions can be very difficult to get right. In some cases (most notably those with values of 90.0 or higher) the plot of measurements shows a perfectly straight line over many decades. But other linear solutions, when you plot the measurements, show a much shorter plot and sometimes the points don't all lie along a nice straight line. This could be partly due to the fact that an

extremely long-period binary star with an orbit nearly edge on to our line of sight would certainly look linear even over several hundred years of observations. I suspect that many of the cases where we see linear motion in the 0.0 to 40.0 range could be just such examples. We may also be dealing with measurement error, especially for close pairs where the error is a larger percentage of the value itself. This could play a significant role for these cases.

### The Anomalies

WDS 05098+2802 BC (Figure 2) has a grade 4 orbit computed by Wulff Heintz in 1976. It scored 62% because the two stars have widely varying proper motions — +103, +16 versus +26, -18. The proper motion data suggest strongly that this is a linear pair. Figure 2 is a plot of the orbit Heintz computed.

As you can see, the micrometric data points (in green) are wildly scattered, while the interferometric points (in blue) are nicely placed on the orbital curve.

### Another Statistical Tool for Evaluating Binary Stars

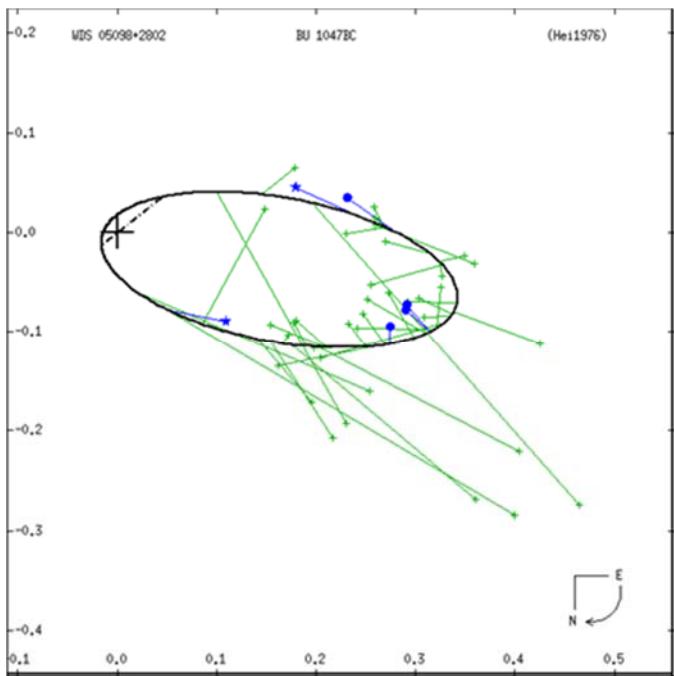


Figure 2. Grade 4 orbit of WDS 05098+2802 BC computed by Wulff Heintz in 1976

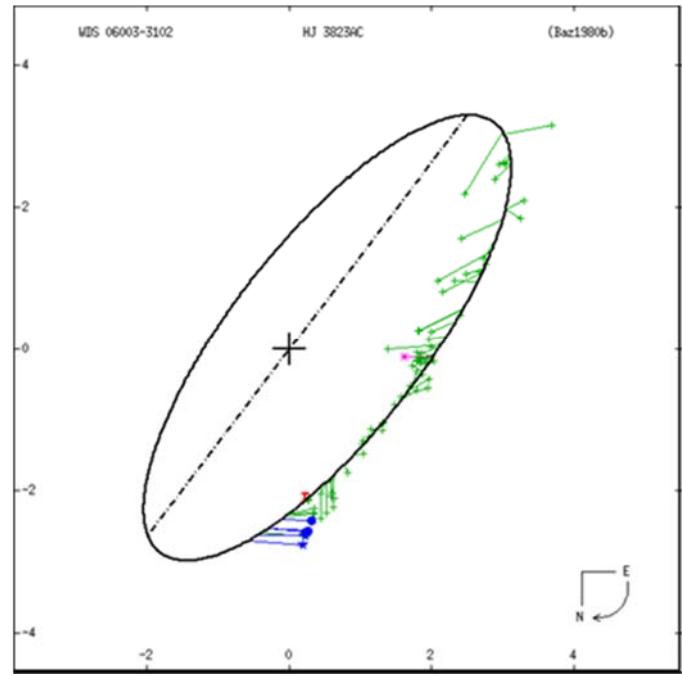


Figure 3. Grade 5 orbit of WDS 06003-3102 as computed by Baize.

Also note that the interferometric data seems to suggest a slightly different orbit than the one computed by Heintz. The micrometric points show so much scatter because this system is at the limits of micrometric measurement. In a pair this close, where an orbit has been solved, differences in proper motion are of no major concern. There could also be an error (typographic or even wrong data) in one or both of the proper motions.

WDS 06003-3102 AC scored 35% and has been assigned a grade of 5. The proper motions of the two stars are  $[-47 +41]$  and  $[-44 +102]$ . The RA numbers are very close together but the DEC numbers make the likelihood of this pair being binary seem low. A solution was derived in 1980 by Paul Baize. A note in the 6<sup>th</sup> Orbit Catalog reads, "This one is the closest to the line and the incomplete orbital coverage of the wider system may be the culprit." Indeed! The plot of the orbit is shown in Figure 3.

To be fair to Baize, the interferometric data were obtained long after Baize derived his orbital solution.

Three other pairs in the orbit list show anomalies. None of them are published in the sixth orbit catalog yet so grades are not available. The first pair is WDS 07366-1429 AB. With an incredible rating of 99.94%, and proper motions of  $[+2 +2]$  and  $[-32 -24]$ , every indication is that this pair is actually optical and not physical.

WDS 09104+6708 AB scored 52% and had proper

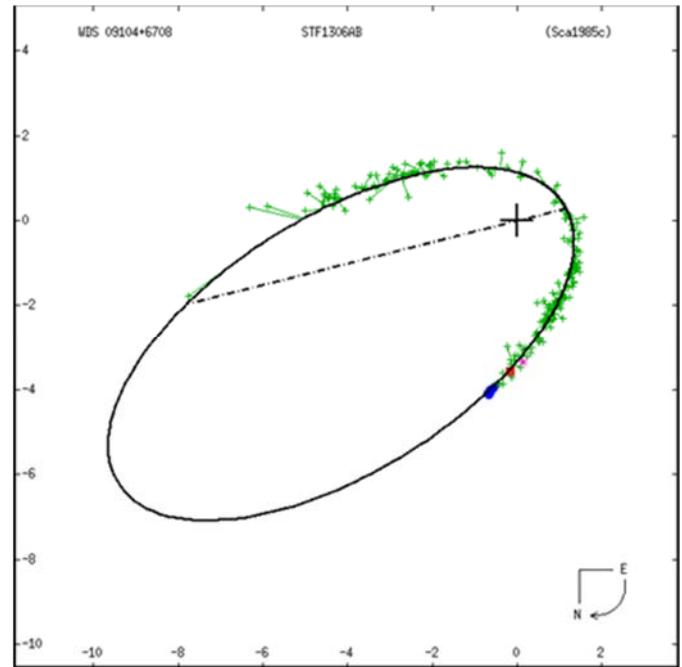


Figure 4. Orbit of WDS 09104+6708 as computed by Scardia.

## Another Statistical Tool for Evaluating Binary Stars

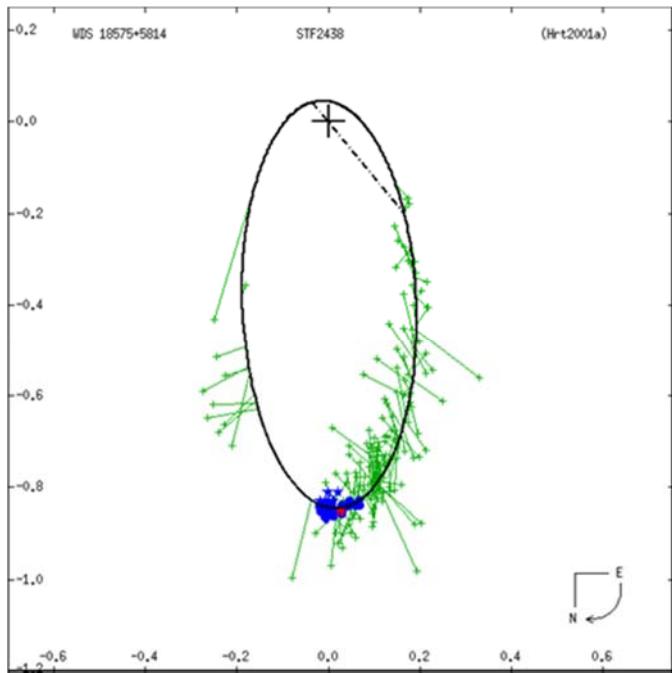


Figure 5. Orbit of WDS 18575+5814.

motions of +7, -95 and +4, -30. The orbit was computed by Scardia in 1985, and the points do indeed lie on a solid ellipse (Figure 4.)

And WDS 18575+5814 scored 65% with proper motions of +4, +37 and +39, +2. The orbital solution looks solid (Figure 5).

I have referred the possibly linear anomaly to William Hartkopf at the US Naval Observatory for possible review of the solutions on record. He replied that the proper motions for the “anomalies” should be rechecked since better data are now available than what was on file at the time of the solutions. In fact, it could be generalized that if the proper motions of a pair that shows obvious orbital motion are very different, then one or both of the proper motions is suspect.

For the linear anomalies, I extracted those systems from Table 2 and they are given in Table 3.

In particular, there are special oddities in this list. Three of these systems also have orbital solutions! They are WDS 03122+3713, WDS 04130-2832, and WDS 02442+4914.

### Conclusions and Recommendations

Whereas earlier statistical criteria were useful to help predict the binary or linear nature of a given system, in this era of greater and greater precision in prop-

er motions, it is becoming increasingly easy to compare the proper motions of both stars in a system. Even now, the US Naval Observatory is working on a project to import proper motion data for all the systems in the WDS from the new UCAC4 catalog. When this project is complete, double star astronomers will have available to them a new and powerful tool to help them know what kind of solution to seek for a pair. As the two cases of clear orbits with high rating scores show, no statistical tool is 100% reliable, but the rating system does help us know what sort of solution to begin working on.

Given the high correlation between the rating score and orbital pairs with equal or very nearly equal proper motions, it is probably safe to say that any time we see a pair with common proper motion, we are probably dealing with a true binary. It would then be necessary to precess the measurements and plot them to look for any signs of elliptical motion. A secondary approach would be to try to obtain parallax data and radial velocity data for both stars in the system. If the parallax is nearly the same and radial velocities are close to each other, the odds of a common proper motion system being binary are much higher.

At the opposite end of the spectrum, when two stars of a system have widely differing proper motions, it is probably best to try to seek a linear solution for that pair (after precessing the measurements and creating a plot).

### Acknowledgments

This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory.

Special thanks to William I. Hartkopf of the US Naval Observatory for filling my insatiable quest for data and for pre-publication review of this manuscript.

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**Another Statistical Tool for Evaluating Binary Stars***Table 3. Linear Anomalies Listed in Order of Increasing Rating*

WDS No.	PM A RA	PM A Dec	PM B RA	PM B Dec	Diff Vec-tor Mag <sup>1</sup>	Mag, Sum of PM	Rating (%)
01417-1119	43	-417	43	-417	0.0	838.4	0.0
03122+3713	-38	-39	-38	-39	0.0	108.9	0.0
04130-2832	90	44	90	44	0.0	200.4	0.0
12095-1151 AB	296	-168	296	-168	0.0	680.7	0.0
13120+3205	15	-6	15	-6	0.0	32.3	0.0
14497+4843	-78	97	-78	97	0.0	248.9	0.0
15261+1810	14	-8	14	-8	0.0	32.2	0.0
22143+1711 AB	-81	-93	-83	-91	2.8	246.5	1.1
10015+6843	-44	-24	-46	-24	2	102.0	2.0
22396-1237 AB	228	-152	228	-165	13.0	555.5	2.3
15169-0817 AB	-102	-237	-100	-225	12.2	504.2	2.4
02556+2652 AB	274	-185	270	-168	17.5	648.6	2.7
12115+5325	-164	-125	-170	-136	12.5	423.9	3.0
12281+4448	-180	-7	-178	4	11.2	358.2	3.1
12151-0715 AB	-250	-53	-241	-69	18.4	506.2	3.6
00028+0208	62	-94	54	-92	8.2	219.3	3.8
23564-0930 AB	-266	-66	-287	-60	21.8	567.3	3.9
22490+6834 AB	114	61	117	73	12.4	267.2	4.6
19368-1027	-271	-299	-300	-263	46.2	802.5	5.8
00458-4155	307	-76	288	-111	39.8	624.9	6.4
00408-0714	9	-102	1	-92	12.8	194.4	6.6
10029+6847	-27	-19	-31	-22	5	71.0	7.0
20517-4054	16	-11	22	-11	6.0	44.0	13.6
23133+2205 AB	4	-50	9	-38	13.0	89.2	14.6
04385+2656 AB	41	-56	41	-88	32.0	166.5	19.2
02442+4914 AB	511	-90	336	-84	175.1	865.3	20.2
20494+1124 AB, C	196	-132	116	-105	84.4	392.8	21.5
20144-0603 AB	37	-1	48	16	20.2	87.6	23.1
21124-1500	78	-40	50	-22	33.3	142.3	23.4
21330+2043 AB	-5	-43	-5	-25	18.0	68.8	26.2
13064+7618	-58	15	-33	10	25.5	94.4	27.0
19074+3230 AC	124	30	122	111	81.0	292.5	27.7
13518-3300	-70	-22	-36	-30	34.9	120.2	29.0



# A Comparison of Two Double Star Astrometry Techniques: Visual and DSLR

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**Abstract:** Three investigators carried out a comparison study involving an astrometric eyepiece and a digital single-lens reflex (DSLR) camera to determine position angles and separations of five double stars. A comparison of the precision and accuracy of each technique was accomplished.

## Introduction

Two students and an experienced double star observer participated in the Pine Mountain Observatory (PMO) Summer Research Workshop July 7-12, 2013. Past double star research projects at PMO all involved visual observations using astrometric eyepieces. In addition to using visual methods, it was decided to use a DSLR camera to measure the same five double stars, and compare the results with those obtained from using the astrometric eyepiece.

The schedule was the following:

First night: Calibrate astrometric eyepiece and visually measure one double star

Second night: Visually measure four additional double stars

Third day/night: Present project outline to workshop participants; then DSLR photography of the same five double stars

Fourth day: Analyze data; present results to workshop participants

The double star team was comprised of three observers with varying experience (Figure 1). Frey, team leader, has been studying double stars since 2007. Hernandez-Frey participated in the 2011 PMO summer workshop. Hartshorn had no astronomy experience. All three investigators equally shared observing and data recording duties.

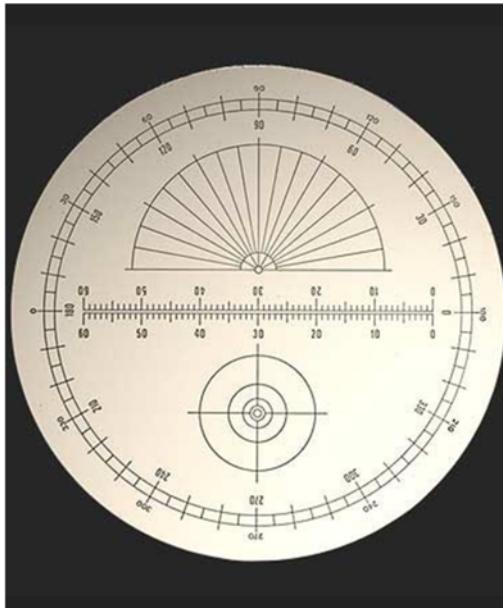


Figure 1. Thomas Frey, Brandon Hartshorn, and Navarre Hernandez-Frey with the 18 inch Obsession alt-az telescope used in the investigation.

## Background

Giovanni Rocciali, an Italian Catholic priest, was one of the first Europeans to note that Mizar in Ursa Major is a double star. But it wasn't until the 1770's that Sir William Herschel began making measurements of double stars as a first step in measuring stellar parallax. Herschel used a filar micrometer, originally developed by William Gascoigne. Filar Micrometers have

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**Figure 2:** Celestron 12.5mm illuminated reticle

been used to measure visual binaries for over 200 years. Visual observations today use reticle astrometric eyepieces as those manufactured by Celestron or Meade. Such laser-etched eyepieces have a linear scale for measuring angular separation and a protractor scale for determining position angle (Figure 2).

Advancing to the digital age, photographic instruments such as the charge-coupled device (CCD) have mainly taken over the task of documenting double star parameters. A majority of astronomers use equatorially mounted telescopes with CCDs rather than alt-az (Dobsonian) mounted telescopes due to field rotation encountered with the latter type of mount that can affect the measurement of position angle. The smallest field rotation experienced by an alt-az telescope would be for observation made directly east or west and close to the horizon [1].

Yet there are many alt-az mounted telescopes in use. One way to circumvent the problem of field rotation would be to take short exposure DSLR photographs of double stars and convert these images into position angle and separation measurements with a series of available software programs (Figure 3).

Therefore our team chose to compare the advantages, disadvantages, precision and accuracy of the astrometric eyepiece and DSLR techniques. Due to the wide range of team experience and that the DSLR technique was a virtually new approach to the team, it seemed like an appropriate project for PMO research.



**Figure 3:** Obsession alt-az telescope with Canon T2i DSLR at prime focus

## Locale and Observing Conditions

The study was carried out at Pine Mountain Observatory, near Bend, Oregon. The site is located at 43.79 degrees north latitude and 120.94 degrees west longitude. The first night of observation we experienced intermittent wind gusts. For the rest of the observing sessions we were rewarded with clear, dry, conditions and moderate to excellent seeing.

## Instrumentation and Software

Our telescope was an 18 inch f/4.5 Newtonian manufactured by Obsession. The astrometric eyepiece was a 12.5 mm Celestron laser illuminated eyepiece. The reticle is shown in Figure 2. The DSLR camera was a Canon T2i. Accurate focus was accomplished by using a Bahtinov mask [2]. The setup is shown in Figure 3. The team used a MacBook Pro equipped with OS 10.8.4 and a partitioned hard drive with Microsoft Windows 7. Utilized software included ImageJ [3], IrfanView [4], and Herbert Raab's Astrometrica [5] to obtain right ascension (RA) and declination (Dec) values of each star. The data were then processed with an Excel spreadsheet [6] to yield the position angle and separation.

## Five Double Stars Studied

Table 1 shows some of the specifications of the double stars investigated. The proper motion is in arc seconds per 1000 years. The spectral types and some parallax data were obtained from SIMBAD [7].

Brian Mason, who maintains the Washington Double Star (WDS) [8] catalog, kindly supplied the historic record of position angle and separation for each of the

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**Table 1:** Data for the five double stars studied.

Object	WDS Ident.	Constellation	SpecType Prim/Secnd	Proper Motion (mas/yr)		Parallax (mas)	
				Primary	Secondary	Primary	Secondary
ES2710	20459+4448	Cygnus	A7V/F2III	+004 -003	-010 -017	20.4200	21.4000
STF2474AB	19091+3436	Lyra	G1V/GV	+056+191	+069+197	23.48*	23.48*
STF2681AC	20228+5325	Cygnus	A0V/A3	+013+016	+032+032	2.23*	7.17*
STF2241AB	17419+7209	Draco	F5IV/G0V	+025-268	+029 -277	45.3800	44.8000
STF2664	20196+1300	Delphinius	K/K0	+009 -014	+011 -014	2.44*	7.59*
				From WDS catalog		* SIMBAD	

five double stars. Tables 2-6 show the first and most recently reported WDS observations along with three other intermediate observations used for comparison with our data. The data show the general trend in changes over the years.

ES 2710 is an optical binary with a separation of 51.1 arc seconds (WDS 2008), which was selected due to its wide separation.

STF 2474AB is reported as part of a four star system in the WDS. The A component is actually an Aa,Ab spectroscopic binary (CHR 84Aa,Ab) with a 0.1 arc second separation. Both Aa and B components are solar-like G stars. There is a report [9] of a low-mass companion orbiting the B star. The planet was detected using radial velocity measurements and has a period of 71.5 days and a minimum mass of 6.3 M<sub>J</sub>. The AC component (WAL 105AC) has a separation of 96.8 arc seconds (WDS 1998).

STF 2681AC is part of a four star system in the WDS. The AB components are separated by 6.9 arc seconds (WDS 2003). The AC components, both A-type stars, are separated by 38.5 arc seconds (WDS 2012). Proper motion and parallax indicate AC components are probably optical double stars.

STF 2241AB is a part of a four star system in the WDS. The AB components are separated by 30.0 arc seconds (WDS 2010). Similar proper motion and parallax suggest the AB components are a binary pair or a common proper motion pair .

STF 2664 is a binary pair of two K-type stars separated by 27.4 arc seconds (WDS 2008).

### Visual Measurements

The determination of the scale constant for the Celestron eyepiece was done using techniques previously described [10]. Briefly, a reference star is allowed to drift along the linear scale with the tracking motors off. The drift time is measured to the nearest 0.01 seconds. The average drift time of 10-20 trials is used to calculate

**Table 2:** Past measurements for ES 2701

Object	Year	PA(deg)	Sep (asec)
ES 2701	1898	80.0	52.93
	1918	80.0	53.60
	1957	80.1	51.90
	1999	80.8	51.38
	2008	80.9	51.10

**Table 3:** Past measurements for STF 2474AB

Object	Year	PA(deg)	Sep (asec)
STF 2474AB	1823	259.5	17.12
	1866	260.0	17.10
	1912	261.1	16.51
	1974	261.9	16.23
	2012	262.9	15.85

**Table 4:** Past measurements for STF 2681AC

Object	Year	PA(deg)	Sep (asec)
STF 2681AC	1831	203.7	41.84
	1901	201.7	40.10
	1949	200.7	39.58
	1999	199.3	38.42
	2012	199.0	38.51

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the scale constant. The double star Dubhe (Alpha Ursae Majoris), was used as the reference. The results are given in Table 7. SD and SEM are the standard deviation and standard error of the mean statistics; they are defined and discussed in section Discussion and Technique Comparison.

Tables 8 and 9 list, respectively, the averaged separation and position angle visual measurements for the five double stars investigated. Separation measurements were made when the tracking motors were engaged. The non-tracking drift method was used to determine the position angle [10]. Also listed for comparison are the WDS measurements for the most recent entry. ES 2701 was measured on Besselian Epoch (BE) 2013.5156. The other four double stars were measured on BE 2013.5183.

### DSLR Technique and Measurements

The following procedure was carried out to obtain the separation and position angle of the five double stars using a Canon T2i DSLR camera, the 18 inch Obsession and a computer. The initial photos were taken in both CR2 and JPEG mode. Focusing was assisted by use of a Bahtinov mask and a small hand magnifier to enlarge the image on the camera screen. The JPEG was examined for saturation and focus with ImageJ software. Once corrected for proper exposure and focus, six sci-

**Table 5:** Past measurements for STF 2241AB

Object	Year	PA(deg)	Sep (asec)
STF 2241AB	1800	14	32
	1857	14.5	30.78
	1912	14.7	30.93
	1949	15.2	30.36
	1980	15.9	30.42
	2010	16.0	29.99

**Table 6:** Past measurements for STF 2241AB

Object	Year	PA(deg)	Sep (asec)
STF 2664	1825	322.8	28.38
	1866	322.3	27.80
	1908	321.9	27.75
	1957	321.2	27.52
	2005	321.6	27.59
	2008	320	27.4

**Table 7:** Scale constant determination

Reference Star	Besselian Epoch	Declination (degs)	# Observat.	Ave. Drift Time(secs)	SD/SEM (sec)	Scale Const. (asec/div)
Dubhe	2013.5156	61.7511	20 (2 outliers)	85.51	0.71/0.16	10.15

**Table 8:** Visual separation measurements for five double stars

Object	WDS Ident.	# Observ.	Literature Epoch	Lit Separ (arc sec)	Obser Separ (arc sec)	SD/SEM (arc sec)
ES2710	20459+4448	12	2008	51.1	51.8	0.343/0.009
STF2474AB	19091+3436	12	2012	15.9	14.8	0.307/0.165
STF2681AC	20228+5325	12	2012	38.5	36.3	0.549/0.159
STF2241AB	17419+7209	12	2010	30.0	30.5	0.027/0.008
STF2664	20196+1300	12	2008	27.4	29.7	0.238/0.069

**Table 9:** Visual position angle measurements for five double stars

Object	WDS Ident.	# Observ.	Literature Epoch	Lit PA (degs)	Obser PA (degs)	SD/SEM (degs)
ES2710	20459+4448	10	2008	81	82.2	0.510/0.161
STF2474AB	19091+3436	10	2012	263	263	1.887/0.770
STF2681AC	20228+5325	10	2012	199	195	1.110/0.621
STF2241AB	17419+7209	9	2010	16	14.5	1.803/0.601
STF2664	20196+1300	10	2008	320	324	1.660/0.525

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ence images were taken in rapid succession and downloaded into iPhoto. The CR2 files were downloaded into Windows 7 on the hard drive partition using the Bootcamp feature on the MacBook Pro. The CR2 files were converted to Tif files using IrfanView. The Tif files were converted into Fits files using ImageJ. The Fits files were reduced in Astrometrica to determine the right ascension (RA) and declination (Dec) for the primary and secondary stars. The position angle and separation were computed with a spreadsheet using Bob Buchheim's equations from R.W.Argyle's text [6].

Tables 10 and 11 list, respectively, the averaged observed DSLR separation and position angle of the five double stars along with the most recently reported WDS literature and visually determined values. All DSLR photos were taken on BE 2013.5211. The SD and SEM listed pertain only to the six DSLR science images for each double star.

### Discussion and Technique Comparison

Hernandez-Frey and Hartshorn accomplished most of the calibration of the astrometric eyepiece after a demonstration by Frey. Twenty observations were carried out mainly to get the students use to manually moving the telescope.

All three observers took visual separation and position angle measurements with the astrometric eyepiece. Twelve separation observations were done for each double star and ten position angle observations were done for each. An outlier caused only 9 position angle measurements to be processed for STF 2241AB. The visual observations were done over two nights so that the students were not too rushed in taking these measurements that involved a lot of manual manipulation of the telescope.

The DSLR photos were all taken in one session. After focusing and saturation issues had been resolved, the six science images were taken.

*Table 10: Visual/DSLR separation measurements for five double stars*

Object	Lit Sep/Epoch (arc sec)	Visual Sep (arc sec)	DSLR Sep (arc sec)	DSLR SD/SEM (arc sec)
ES 2710	51.1/2008	51.8	50.857	0.345/0.141
STF 2474AB	15.9/2012	14.8	15.624	0.462/0.189
STF 2681AC	38.5/2012	36.3	38.790	0.724/0.296
STF 2241AB	30.0/2010	30.5	30.028	0.806/0.329
STF 2664	27.4/2008	29.7	27.309	0.473/0.193

*Table 11: Visual/DSLR position angle measurements for five double stars*

Object	Lit PA/Epoch (degs)	Visual PA (degs)	DSLR PA (degs)	DSLR SD/SEM (degs)
ES 2710	81/2008	82.2	80.434	0.444/0.181
STF 2474AB	263/2012	263	262.197	1.430/0.584
STF 2681AC	199/2012	195	200.071	1.505/0.615
STF 2241AB	16/2010	14.5	16.232	1.772/0.723
STF 2664	320/2008	324	321.818	0.282/0.115

## A Comparison of Two Double Star Astrometry Techniques: Visual and DSLR

The different division of labor between the two techniques became obvious. With the visual method, the observer's share of time involved observation at the eyepiece and recording data. The determination of averages and statistical data required much less time. The reverse was true for the digital camera method. Once focus and saturation issues had been solved, the recording of the science images went rapidly. Then this data was downloaded into the computer, CR2 files needed to be converted to Fits file, and then reduced by Astrometrica. Each of the 30 science images needed to be reduced separately, which took some finesse. Then right ascension and declination values for each component (60 total each) required conversion to position angle and separation with the spreadsheet. At the workshop we only had time to reduce 1-2 images for each target before preparing the power point presentation for the workshop participants. All six images of each target were processed later.

Double star research should involve some statistical analysis to evaluate the precision of the measurements. Two functions are calculated for this project. Standard deviation (SD) represents the spread of numbers in a series of measurements. The smaller the SD the more tightly grouped and precise are the measurements. For a bell curve, approximately 68% of the data are within  $\pm 1$  standard deviation. The standard error of the mean (SEM) is also determined. In scientific studies multiple

measurements are mandatory to reduce random error and observer bias. The SEM takes this into account; it is the standard deviation divided by the square root of the number of observations. The greater the number of observations recorded, the smaller the SEM.

We noticed that there was quite a spread of standard deviations among the five targets when comparing visual and DSLR methods. We also thought it would be interesting to check the variance of a particular target by checking: 1) SD and SEM of six different images of the same star; and 2) SD and SEM of the same image reduced six times.

This analysis would show if there was a significant difference in how each image was processed. STF 2664 was chosen for this test. All images for this double star were taken at ISO 800 with an exposure of 0.5 seconds. These data are shown in Table 12.

The standard deviation of the position angle where all images were the same (all 6073 reduced six times) was 40.33% of the standard deviation of the position angle where six different images (6073-6078) were reduced. The standard deviation of the separation where all images were the same was only 9.02% of the standard deviation of the separation where six different images were reduced. It showed that the “all the same image” standard deviation values had a much tighter grouping than the six different image reduction. Yet the “same image” po-

**Table 12:** DSLR statistical comparisons of STF 2664; six different images and same image six times.

Object	STF 2664; different images		Object	STF 2664; same image	
Image	Position Angle	Separation	Image	Position Angle	Separation
6073	321.85401	27.21128	6073.1	321.854011	27.221281
6074	321.85401	27.21128	6073.2	321.854011	27.221281
6075	321.79822	26.4686	6073.3	321.854017	27.2212787
6076	322.12812	27.61645	6073.4	321.854011	27.221281
6077	322.03295	28.03275	6073.5	321.612797	27.3017968
6078	321.24223	27.31475	6073.6	321.612797	27.3017968
<b>Average</b>			<b>Average</b>		
	321.818257	27.309185		321.773607	27.2414526
<b>Std Dev</b>			<b>Std Dev</b>		
	0.28192	0.473241		0.113710	0.0426698
<b>SEM</b>			<b>SEM</b>		
	0.11511	0.193239		0.046431	0.0174234

## A Comparison of Two Double Star Astrometry Techniques: Visual and DSLR

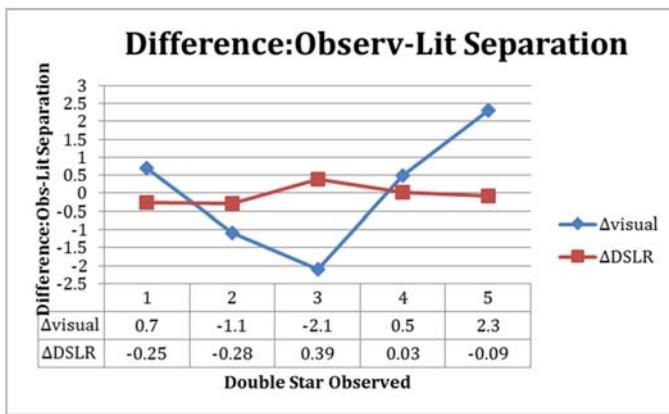


Figure 4. Difference between observed and literature separation values (arc seconds) for visual and DSLR data.

sition angle values with SD 0.1137 were scattered to a greater extent than the corresponding “same image” separation values with SD 0.0427. And both the position angle and separation SD values for “same image” were measurably lower than the corresponding “six different image” statistics. So clicking on the star image in Astrometrica (e.g. the placement of the crosshairs) affected the distribution of the position angle orientation more than the separation between components. This suggests that additional images should be taken and processed. Most of the six star images for each double star were round but some were elongated or smeared due to camera movement. With additional images, selection of only the roundest images should be used for Astrometrica reduction to give more accurate and precise results.

When the differences between the observed values and the most recently reported WDS literature values of separation and position angle for both visual and DSLR methods were compared, an interesting correlation developed. Figure 4 plots the difference between the observed and the latest reported WDS literature separation (Y-axis) in arc seconds vs target double stars on the X-axis. Figure 5 plots the difference between the observed and literature position angle (Y-axis) in degrees vs target double stars on the X-axis. The target double stars are numbered to clarify the chart display:

Double Star Number	Double Star Number
ES 2701	1
STF 2474AB	2
STF 2681AC	3
STF 2241AB	4
STF 2664	5

Figure 4 shows the range of the difference between observed and the latest reported WDS literature separation values. They varied over 4.4 arc seconds for the visual observations and only 0.67 arc seconds for the DSLR observations. For the astrometric eyepiece values, this 4.4 arc seconds only differed by 43% of one divi-

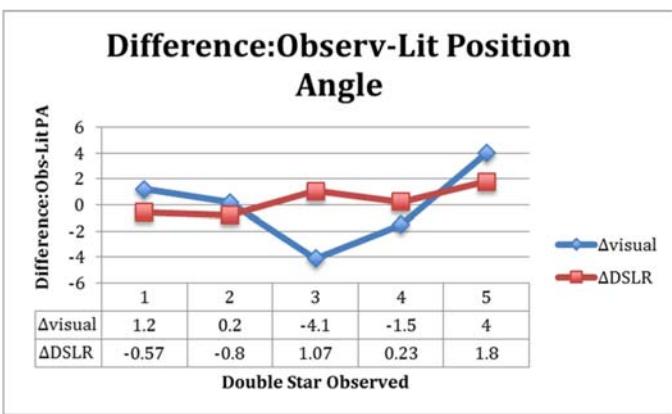


Figure 5: Difference between observed and literature position angle values (degrees) for visual and DSLR data.

sion on the linear scale. Yet the DSLR range of 0.67 arc seconds was only 15% of the visual range. This showed a tight group distribution for DSLR and closer to the literature values. Also, the large range in separations for the targets were chosen to see how well the DSLR technique could handle both large and small separations during reduction. The concern is as the separations got closer that the images might merge and prevent a good reduction. This concern was eliminated when it was shown the double star with the smallest separation, STF 2474AB (15.9 asec), was easily reduced by Astrometrica.

Figure 5 shows the range of difference between the observed and the latest reported WDS literature position angle values. They varied from 8.1 degrees for the visual observations and only 2.6 degrees for the DSLR data. The fairly large range in the visual position angle values for an alt-az telescope always comes down to two situations: (1) field rotation and/or (2) inherent difficulty in lining up the two stars on the linear scale prior to using the drift method to obtain the position angle. There is little correlation between the alignment problem on the linear scale and separation since the two smallest differences (1.2 degs for ES 2701 and 0.2 degs for STF 2474AB) also have the highest and lowest separations (51.1 asec for ES 2701 and 16.0 asec for STF 2474AB). Yet the information on Tables 8 and 9 shows that STF 2474AB, with the smallest separation studied, 15.9 arc seconds, had the largest SD (so the largest data spread) for position angle data in the visual study. This indicates the difficulty in aligning two stars on the linear scale that are only about 1.5 divisions apart, contributed to the larger SD. The use of a Barlow lens with closer pairs might have helped visually and should be considered in future studies.

It should be mentioned that the most recent WDS literature values listed in Tables 8 and 9 were not pre-

## A Comparison of Two Double Star Astrometry Techniques: Visual and DSLR

cessed to J2000 values. Future studies should include this computation for more accurate comparison between observed and literature values.

The altitude of the double star may also have been a factor in the large visual position angle range. The closer to the zenith the double star, the harder it is to maneuver the telescope to allow for proper drift. But we have no direct evidence to account for this in the present study.

The DSLR position angle range of 2.6 degrees is only 32% of the visual range. Taking the photographs over short exposures captures the parameters and stores them more efficiently and does not suffer the problems of field rotation, improper alignment and extended drift times.

### Repeatability of Measurements

Figure 6 shows one of the double stars studied at PMO. It plots the right ascension on the X-axis and the declination on the Y-axis for STF 2474AB. The left graph shows the primary star positions for six different images; the right graph shows the secondary star positions. This shows six different photo images taken. Note the exponential number on the far right of the X-axis. This value is to be added to the value indicated on the X-axis to determine the actual value in degrees. A similar value is at the top of the Y-axis for the declination. In the left graph we see how the primary stars are closely grouped and the slight spread and change of position angle of the secondary stars on the right. The circles centered on the averages in each graph correspond to 0.500 arc second radii.

Figure 7 shows the same double star, STF 2474AB, as in Figure 6. But in Figure 7, the same image (6048) was reduced six times with Astrometrica. Again, it plots the right ascension on the X-axis and the declination on the Y-axis. Note the very tight grouping indicated by the three circles in each graph. And, in Figure 7, the circles only represent 0.100 arc second radii. This shows that variance in solving the same image is very small; the SD for the separation and position angle values in Figure 7 are 0.1475 and 0.3977, respectively. This indicates that reducing the same image in Astrometrica multiple times shows little change in the generated right ascension and declination results compared to reducing multiple different images. This shows a high reproducibility when using Astrometrica.

### Summary of the Advantages and Disadvantages of Each Technique

Advantages and disadvantages of the visual astrometric eyepiece method are:

#### Advantages

- Inexpensive; the eyepiece cost about \$150

- Short setup time
- Easily understood introduction to double star astrometry
- Disadvantages**
- Lots of time spent at the eyepiece making many observations to avoid random error and bias
- With alt-az telescopes, field rotation occurs; this is maximum in the north, south and at the zenith
- Scintillation effects make the star images jump around making readings difficult for both separation and position angle
- Wind gusts make position angle drift measurements prone to error

Advantages and disadvantages of the DSLR photographic method are:

#### Advantages

- Rapid image exposure time (0.15-1.5 seconds); can record many digital images in a few minutes
- Can effectively measure separations less than 15 arc seconds using Astrometrica
- There is an increase in accuracy and precision
- Permanent images are stored for later study
- Lots of software is available to reduce photographic data
- Disadvantages**
- Equipment is more expensive: camera, computer, some software
- Processing many images to determine parameters takes more time

The team felt that both techniques have their place in double star research. The hands-on astrometric eyepiece method is a good introduction to the science and the DSLR camera technique has the advantage of less time in the field and greater overall accuracy and precision.

### Workshop Reflections

Hernandez-Frey (NHF) had attended PMO in 2011 and worked with a group of 5 students making visual double star observations [11]. Hartshorn (BH) had never done any astronomy science and said he had never seen the Milky Way prior to the PMO workshop. Team leader Frey (TF) asked both students for a summary of their experiences at PMO in 2013. Paraphrased summaries of their statements are given below.

[NHF]: *The research exposed me to new types of technology that could be used to analyze the universe. I couldn't possibly comprehend this unless I saw it with my own eyes. A skill I gained was how to accurately take measurements with the telescope as well as documenting*

## A Comparison of Two Double Star Astrometry Techniques: Visual and DSLR

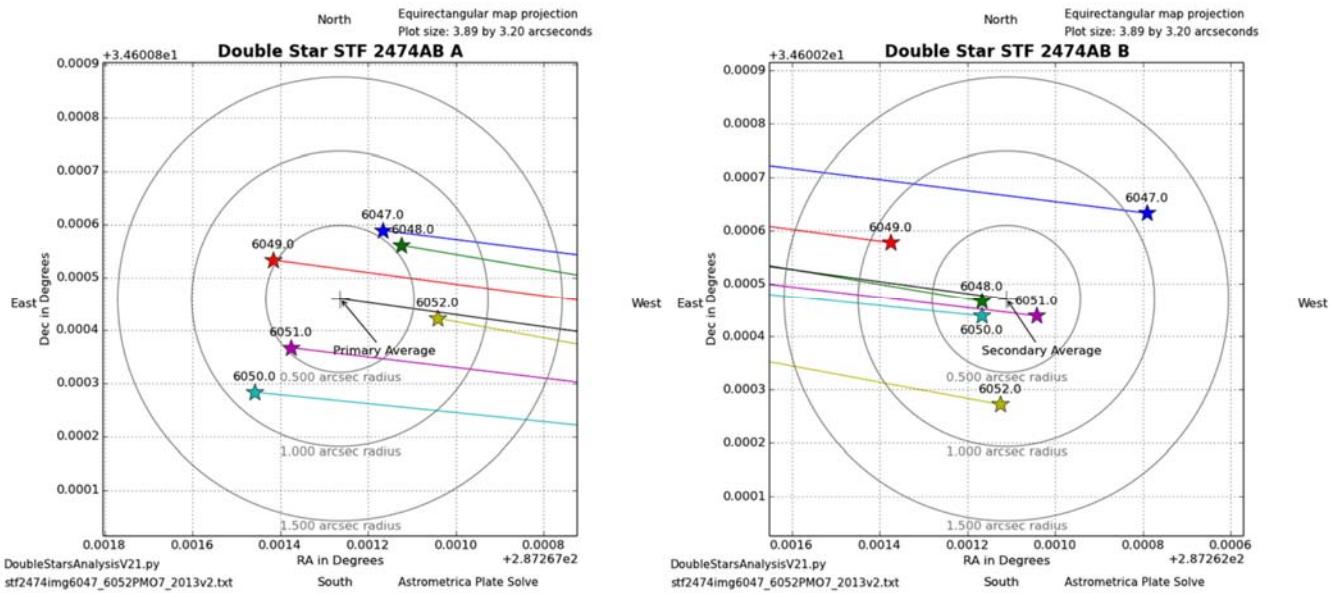


Figure 6. STF 2474AB primary and secondary star coordinates and their averages, showing the general grouping and changes in position angle. Data is taken from images 6047-6052.

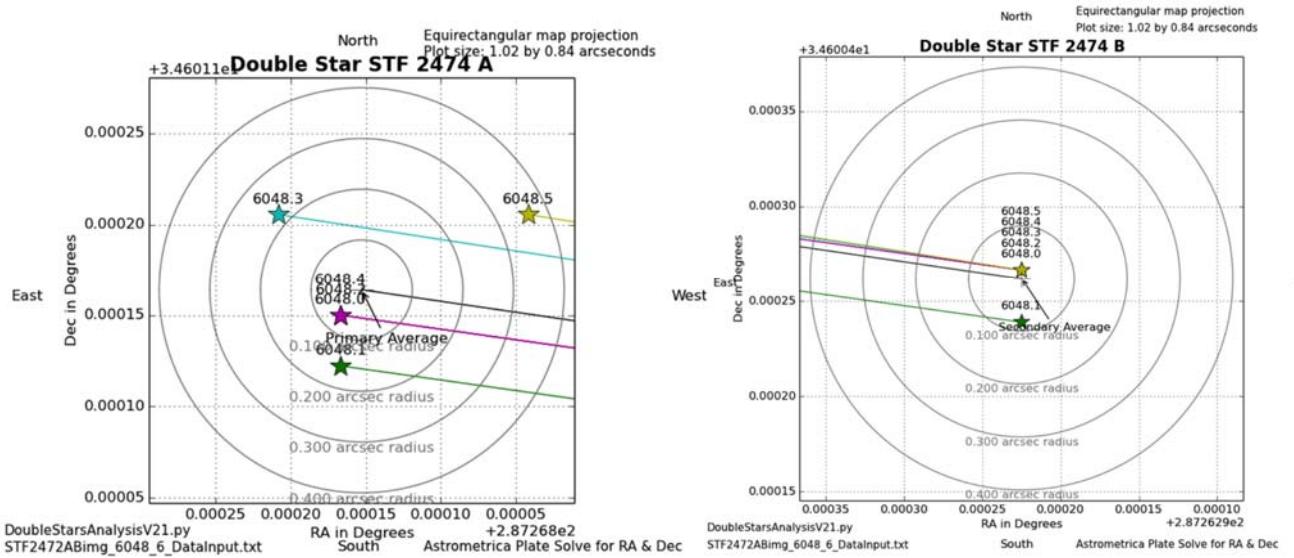


Figure 7. STF 2474AB primary and secondary star coordinates and their averages, showing the general grouping and changes in position angle. Data is taken from image 6048 alone.

the results. My team had gathered extensive information also showed that everyone could enjoy the process. I on five double stars. I believe the DSLR technique was a learned a lot more at this, my second workshop, since I more viable option because it contributed results closer had an idea of the goals from the first PMO workshop. to WDS values than the astrometric eyepiece method. [BH]: The most rewarding aspect of the PMO work- Also, the DSLR technique only took one night to gather shop was the chance to see the true beauty and complex- the data whereas using the astrometric eyepiece took ity of double stars. I realized calculating the distance two nights. So I preferred the DSLR technique. I did between two celestial objects involve interesting meth- have fun working with my team but also met individuals ods. The most challenging part of the workshop was tak- from other groups. The workshop, while challenging, ing the astrometric eyepiece measurements that required

## A Comparison of Two Double Star Astrometry Techniques: Visual and DSLR

*a steady hand and sharp eyes. Even though this was the most challenging aspect, I do believe that it is a very essential piece to fully understand astrometric measurements. The hands-on experience of getting to physically use the telescope and take measurements with my own eyes was phenomenal. The DSLR method was much faster, but I did not have the same wondrous feeling as working with the Celestron eyepiece. I do not believe that the DSLR method, though very effective, should be done solely with beginning astronomers like me, because I received a better understanding of the measurements using the astrometric eyepiece. The workshop was a mind broadening experience. This brilliant new view of the universe has taught me that while the world is a big complex place, the universe is an ever changing carrier that houses countless stars and galaxies. I am very glad that my eyes have been opened by this experience.*

### Acknowledgements

The team would like to express its thanks to Russ Genet, Joseph Carro and David Haworth for reviewing this paper and for their suggestions. A special thanks goes to David Haworth for generating Figures 6 and 7. We would also like to thank the Pine Mountain Observatory staff, especially Allan Chambers, for opening the facility and for being on hand to answer questions and assist our needs. And gratitude is extended to Professor Rick Watkins who directed the workshop of 30 participants.

This research made use of the SIMBAD database, operated at CDS, Strasbourg, France, and the Washington Double Star Catalog maintained by the United States Naval Observatory.

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*Thomas Frey is a Professor Emeritus of Chemistry at California Polytechnic State University. He was a Team Leader at the PMO workshop in 2009 and 2013, the Principle Investigator of the double star group at the PMO workshop in 2010, and the co-director of the PMO workshop in 2011. Navarre Hernandez-Frey and Brandon Hartshorn are both high school seniors and both enrolled as sophomores at Bellevue College as participants of the Running Start Program. Navarre attended the PMO summer workshop in 2011 and that was his first contact with astronomy research. PMO 2013 was Brandon's first experience with astrometric measurements.*

# Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars

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**Abstract:** The position angle, separation and spectral class of 753 common proper motion red dwarf binary stars are reported based on data-mining the Sloan Digital Sky Survey Data Release 9. 290 of these are new discoveries.

The aim of this investigation was to combine the proper motion and photometric results from the Sloan Digital Sky Survey (SDSS) Data Release 9 (Ahn *et al.* 2012) with the earlier work on M dwarf stars authored by West, A. A. et al. (2011). This earlier paper used the SDSS (r-i) and SDSS (i-z) magnitudes as a predictive tool to allocate stars to the sub-types between M0 and M9 inclusive, see Table 1.

The SDSS Data Release 9 offers a number of significant advantages over both Data Release 7 and Data Release 8. The proper motion values in DR7 had systematic errors due to the galaxy sample used as a reference frame being contaminated with stars and the as-

trometry errors introduced in the DR8 catalog have been corrected in DR9.

Other researchers such as Cabellero (2012) have used earlier data releases from SDSS as a source of potential common proper motion pairs but, regardless of the source of data to be searched, if the criteria used to identify such pairs are too lenient there will be large numbers of “false positives” in the resulting list.

The decision was made to make the selection criteria rigorous by requiring both components to have a minimum total proper motion of 60 mas/yr and, perhaps more importantly, requiring a close match in the proper motion in both right ascension and in declination.

Table 1: Main feature of M type dwarf stars

Spectral Type M+	Median colours (West <i>et al.</i> , 2011)		Relative to the sun				Main sequence lifetime
	SDSS (r-i)	SDSS (i-z)	Mass	Radius	Luminosity	Teff (K)	
0	0.56	0.33	60%	62%	7.20%	3800	
1	0.73	0.41	49%	49%	3.50%	3600	
2	0.96	0.53	44%	44%	2.30%	3400	
3	1.13	0.61	36%	39%	1.50%	3250	
4	1.33	0.71	20%	26%	0.56%	3100	1.5 trillion years
5	1.62	0.9	14%	20%	0.22%	2800	
6	1.92	1.05	10%	15%	0.09%	2600	6 trillion years
7	2.09	1.14	9%	12%	0.05%	2500	
8	2.56	1.41	8%	11%	0.03%	2400	
9	2.7	1.71	7.50%	8%	0.02%	2300	8 trillion years

## Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars

### Method

Step 1 – The astrometric, photometric and positional data for all stars was downloaded using a SQL query at <http://skyserver.sdss3.org/casjobs/login.aspx> where the proper motion in right ascension or in declination was outside the range -60 to +60 mas/yr.

Step 2 – All pairs of stars where the components are within 120 arcsec were identified.

Step 3 – The designation of the primary star was allocated on the basis of the SDSS r-band magnitude allowing the separation (in arcsec) and the position angle (in degrees) between the two components to be calculated.

Step 4 – All pairs where the differences between the proper motions of the primary and secondary stars are greater than 5 mas/yr in either right ascension or in declination were deleted.

Step 5 – Any remaining pairs were allocated to one of two groups. The first group was for those that could be matched to a pair already listed in the Washington Visual Double Star Catalog (Mason et al., 2001-2013). The second group was for new discoveries.

### Results and Discussion

A total of 753 common proper motion pairs were identified where both components had the SDSS (r-i) and SDSS (i-z) colours characteristic of red dwarf stars.

It can be seen in Table 2 that the new discoveries tended to be fainter, slower moving and more widely separated than those common proper motion pairs already listed in the WDS catalog.

All the primary and secondary stars were checked against a range of other catalogs to ensure that they were genuine objects and not artifacts introduced during the compilation of the Sloan Digital Sky Survey. This was particularly important where the stars had not previously been identified as being part of a common proper motion binary star system. Each primary and secondary star was checked against:

- 2MASS All-Sky Catalog of Point Sources (Cutri+ 2003)
- Palomar Transient Factory (PTF) photometric catalog 1.0 (Ofek+, 2012)
- The PPMXL Catalog (Roeser+ 2010)
- WISE All-Sky Data Release (Cutri+ 2012)

Table 3 shows the results of the matching. There were just five stars that could not be matched against any of these catalogs. These were all confirmed on the SDSS images available via <http://skyserver.sdss3.org/public/en/tools/chart/list.asp>.

For pairs that were already listed in the Washington Visual Double Star Catalog it is worth noting that the position angle and separation calculated using the SDSS data were in every case very similar to the most recent results available from the Vizier site (<http://vizier.u-strasbg.fr/viz-bin/VizieR>).

What is of more scientific interest is the identification of all these binary star systems as being common proper motion pairs with both components having the typical SDSS colors for red dwarf stars. The quoted spectral sub-classes (M0 to M9) are based on the results obtained by West. As there is some overlap between the different colours (r-i) and (i-z) associated with each subclass the quoted values should be taken as being  $\pm 1$ . In almost every case the primary star is either of an earlier spectral type than the secondary star or is of the same spectral type. This was to be expected since both components are at virtually the same distance from the observer and early M dwarfs are more luminous than later M dwarfs.

For binary pairs that were previously unreported an additional check was carried out. Images obtained from the POSS1 and the POSS2 surveys were downloaded from the Digitized Sky Survey ([http://archive.stsci.edu/cgi-bin/dss\\_form](http://archive.stsci.edu/cgi-bin/dss_form)) and “blinked” using the software package MaxIm (<http://www.cyanogen.com/>). Only those pairs showing clear evidence of motion have been

*Table 2a: The distribution of angular separations between the two classes*

SEPARATION (ARCSEC)	PAIR ALREADY IN WDS	NEW DISCOVERIES
0-20	207	83
20-40	141	66
40-60	56	33
60-80	29	38
80-100	12	36
100-120	10	42

*Table 2b: The key characteristics of the two classes*

CHARACTERISTIC	PAIR ALREADY IN WDS	NEW DISCOVERIES
MEAN PRIMARY MAGNITUDE	15.42	16.83
MEAN SECONDARY MAGNITUDE	16.93	18.43
SEPARATION	29.23 as	50.62 as
MEAN PROPER MOTION (RA)	85.4 as/yr	39.1 as/yr
MEAN PROPER MOTION (DEC)	76.9 as/yr	63.1 as/yr <i>(Continued on page 64)</i>

## Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars

*Table 3 – Matching the SDSS observation to other catalogs*

Catalog	Mean offset	Number of matches	Success rate
2MASS	0.63 arcsec	1437/1506	95.4%
Palomar	0.56 arcsec	512/1506	40.0%
PPMXL	0.55 arcsec	1489/1506	98.9%
Wise	0.60 arc sec	813/1506	54.0%

included in this study.

### Conclusions

Combining data from a number of on-line sources increases the chances of distinguishing between genuine binary star systems and random alignments of stars. Providing the emphasis is always on the quality rather than the quantity of any discoveries claimed by the researcher it is still possible for the amateur data miner to add useful results to the standard catalogs.

The distinction between a visual binary, a common proper motion binary and two members of a larger moving group that just happen to be close together in the sky is not well defined. It is likely that members of all three of these groups could be data-mined from the Sloan Digital Sky Survey (SDSS) Data Release 9.

### Acknowledgements

This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory and the VizieR database of astronomical catalogs, as maintained at the Centre de Données Astronomiques, Strasbourg, France.

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The SDSS-III web site is <http://www.sdss3.org/>.

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University of Portsmouth, Princeton University, the Spanish Participation Group, University of Tokyo, University of Utah, Vanderbilt University, University of Virginia, University of Washington, and Yale University.

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The table of results begins on the next page.

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
1.4044	-1.6654	15.42	16.81	336.71	19.00	2008.830	323.9	127.7	325.7	128.7	LDS 3012
1.6852	-0.9035	14.81	16.78	90.98	81.56	2001.882	76.0	-16.5	74.3	-19.2	GWP 13
1.8549	-5.3131	15.46	18.49	359.58	10.51	2006.711	-28.4	-60.8	-28.4	-60.2	GWP 15
2.1427	18.8297	16.09	16.25	106.67	11.26	2009.057	132.1	-15.2	131.8	-18.0	LDS 3126
2.4115	1.8063	14.68	16.50	9.39	10.89	2008.756	82.6	-39.2	83.6	-36.4	GWP 22
2.4421	23.9435	17.19	17.68	265.51	15.85	2004.729	146.4	1.3	145.4	-3.4	LDS 3131
2.6793	34.2905	15.13	17.55	221.90	43.19	2002.763	-4.3	-81.1	-3.3	-80.9	NEW
3.6267	21.3149	14.87	17.23	26.16	10.72	2009.071	89.9	49.8	92.2	50.8	LDS 3141
3.8319	17.8980	17.33	18.42	272.69	25.22	2008.754	130.6	-158.8	130.5	-158.6	LDS 3145
4.2745	-12.0791	15.99	16.46	117.47	80.25	2006.711	88.7	-15.9	88.0	-11.1	CBL 202
4.5137	-6.5172	15.22	15.82	334.66	21.22	2009.788	47.9	-74.4	45.5	-72.0	GWP 37
4.9296	19.8531	14.69	14.90	262.77	52.93	2009.789	71.7	-45.1	73.7	-44.5	GWP 40
5.2741	-10.0117	14.33	15.84	208.11	64.48	2000.740	95.9	-29.2	96.0	-31.0	LDS 5268
5.4128	21.7372	16.97	17.87	336.74	13.22	2009.071	-21.8	-87.0	-23.9	-84.2	NEW
5.4547	8.8241	15.61	20.28	295.86	20.42	2008.836	27.8	-87.9	26.7	-92.4	NEW
6.0506	15.0750	14.93	16.66	341.19	30.49	2001.715	-22.0	-63.0	-22.4	-63.2	GWP 44
6.1267	36.5557	16.33	18.98	70.25	30.38	2002.763	57.3	-72.9	59.4	-72.8	CRB 27
6.2231	13.9184	17.03	17.80	221.70	51.42	2001.715	-11.2	-111.7	-10.7	-110.7	GWP 45
6.3559	26.0631	13.73	17.84	71.70	42.19	2009.737	-114.8	-198.4	-114.9	-198.8	LDS 3166
6.4710	-9.1188	13.66	15.02	334.52	80.37	2000.737	11.7	-63.3	8.4	-67.0	GWP 48
6.7456	-1.4262	14.49	18.79	53.55	19.92	2008.830	30.0	-96.8	30.0	-98.6	GWP 50
6.7699	-6.4551	16.46	19.07	228.52	19.57	2009.788	-29.8	-186.3	-26.2	-187.8	LDS 3169
7.2477	-9.5794	13.50	14.49	164.05	47.70	2000.740	336.2	-598.9	335.0	-597.0	GIC 10
7.9124	12.1549	13.87	17.09	96.87	83.90	2008.839	-22.8	-84.9	-22.1	-86.8	NEW
8.1133	14.4490	15.31	15.94	152.99	39.49	2000.915	82.3	-27.7	80.0	-25.8	GRV 975
8.5745	26.9980	15.49	16.41	302.52	24.10	2008.817	84.9	14.5	83.5	14.3	NEW
8.9132	19.4773	16.61	17.33	281.21	54.11	2009.046	-77.1	-68.8	-76.9	-72.9	NEW
8.9144	19.4055	16.11	17.51	252.73	51.21	2009.046	90.6	-12.8	89.2	-12.9	NEW
9.7764	27.0619	16.12	16.37	353.62	11.65	2009.792	-41.6	-112.3	-39.5	-109.7	AZC 5
9.7967	34.4952	16.62	17.59	291.07	14.54	2006.753	75.0	28.8	78.1	31.0	CRB 31
9.9562	28.2812	17.51	17.86	350.73	19.52	2009.792	-79.0	-127.2	-75.4	-126.4	LDS 3187
10.0125	-20.9960	18.15	19.46	313.02	17.01	2006.711	56.3	-77.4	53.8	-80.5	SLW 35
10.6490	32.2209	15.63	17.15	76.93	17.22	2009.876	78.8	-5.5	83.0	-6.4	CRB 32
10.7680	29.6904	13.79	17.48	20.66	71.39	2009.792	-75.3	17.9	-72.8	17.1	NEW
10.7878	-22.1988	16.48	16.78	36.03	29.30	2006.744	65.1	28.2	60.9	29.9	NEW
10.7979	-4.0289	14.63	17.66	180.90	15.61	2008.997	60.3	16.6	60.2	14.9	NEW
12.1660	12.4297	15.62	17.72	80.10	104.75	2008.839	67.1	4.1	65.3	5.1	NEW
12.7719	22.5095	16.60	17.69	112.33	13.75	2009.071	55.6	-65.7	53.0	-62.9	AZC 7
12.9979	34.5433	14.18	15.68	130.67	49.43	2008.820	-79.5	17.5	-80.2	15.6	UC 450
13.4329	-3.6179	18.21	18.45	302.13	7.22	2009.043	-10.0	-81.4	-6.5	-81.0	NEW
13.7828	31.0324	14.74	15.37	219.16	12.84	2009.794	65.4	-25.1	64.1	-26.0	CRB 36
14.1045	5.8013	14.89	15.52	219.68	10.15	2008.770	22.4	-68.6	19.8	-71.9	GWP 105
14.3928	2.2630	15.91	16.43	122.74	113.23	2008.754	69.0	2.6	68.9	4.9	NEW
14.4232	4.6839	14.17	15.98	358.20	52.27	2008.770	-41.2	-113.6	-37.5	-111.0	GWP 107
14.4819	-3.4199	15.78	17.03	115.43	27.75	2008.830	-23.6	-77.9	-21.9	-77.3	NEW
14.7040	10.7366	15.40	17.43	212.35	14.48	2008.836	66.5	-24.5	69.1	-22.6	GWP 109
15.0241	12.7700	15.62	17.57	138.46	16.39	2008.839	63.1	-55.2	61.6	-53.7	GWP 113
15.3423	27.9828	14.92	17.34	16.89	27.21	2009.737	-114.7	-75.4	-113.4	-70.5	LDS 3219
15.5773	0.4275	14.68	17.53	0.49	63.93	2003.886	80.7	-27.6	83.8	-30.2	CBL 205
16.1629	32.4891	14.55	16.21	197.20	82.47	2009.794	-84.5	-84.6	-79.9	-82.6	LDS 3227

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
16.7226	23.6802	17.07	19.12	273.09	7.70	2009.737	2.4	-67.4	-1.2	-63.7	NEW
18.1427	-4.7024	15.91	17.57	173.22	47.62	2008.997	185.8	-59.7	185.7	-61.9	LDS 3245
19.3855	25.4217	17.54	17.68	346.95	19.00	2004.707	-24.7	-61.9	-27.3	-64.2	NEW
19.8912	24.8322	15.90	16.18	266.24	64.53	2004.707	-11.7	-73.0	-9.4	-71.4	CBL 209
19.9617	25.4935	15.03	17.53	265.88	15.98	2004.707	64.8	-25.3	64.4	-23.9	SLW 63
20.1468	6.7028	16.15	17.11	291.18	11.26	2005.737	58.0	-83.4	55.6	-85.3	LDS 3265
20.2545	23.9330	13.23	14.20	279.88	67.09	2004.707	148.0	-48.2	149.0	-48.7	LDS 877
20.6151	34.8650	16.34	18.13	0.20	7.13	2008.833	30.5	-74.6	29.8	-71.7	NEW
20.8470	1.8699	17.47	17.87	67.98	8.22	2009.740	-28.1	-149.3	-23.6	-147.5	NEW
20.9674	0.8304	15.18	15.30	191.12	20.47	2003.735	-53.7	-64.8	-52.5	-60.0	GWP 182
21.2060	39.7912	16.92	18.00	1.01	8.53	2004.708	27.7	-75.7	23.9	-76.2	NEW
21.2129	18.0431	15.21	16.64	261.66	30.28	2008.754	103.9	30.1	106.7	30.3	LDS 3274
21.6531	0.6252	16.03	17.53	96.55	12.46	2003.886	0.3	-64.0	-1.5	-66.2	CLZ 8
21.8609	-8.9215	15.52	16.11	317.55	39.10	2005.931	83.1	-15.4	81.5	-12.9	GWP 191
23.2800	-6.0364	17.38	17.62	2.05	17.16	2009.743	178.6	-72.6	180.0	-75.8	LDS 3290
24.2903	-3.0913	16.23	19.91	30.52	10.55	2008.833	-35.8	-76.5	-33.4	-75.4	GWP 203
25.3499	32.2633	14.79	14.90	114.50	51.89	2008.820	-129.4	-33.7	-130.7	-33.0	LDS 1111
25.8692	15.6464	15.10	16.74	342.61	13.86	2008.926	99.8	4.4	99.9	3.8	NEW
25.9382	-17.1922	17.96	18.93	166.41	10.73	2006.881	-62.3	-67.6	-64.0	-67.2	NEW
25.9454	19.9057	16.94	17.10	38.14	13.08	2009.046	-0.2	-71.1	0.1	-71.5	GWP 216
26.4582	20.9601	16.20	18.56	67.32	23.87	2009.049	-77.1	-62.7	-77.5	-63.3	AZC 15
26.4965	21.0957	15.67	15.97	170.66	27.73	2009.071	38.4	-127.5	37.7	-127.0	LDS 3308
26.9896	-6.8728	15.97	17.23	165.62	11.01	2009.044	71.4	52.6	71.9	53.2	NEW
27.1030	28.3934	17.79	19.31	199.64	18.46	2009.792	5.1	80.2	7.5	81.2	NEW
27.2776	6.4010	12.12	12.54	315.84	46.13	2005.781	134.9	-19.2	134.0	-19.9	LDS 3315
27.3071	65.0911	19.56	19.71	109.87	48.13	2005.841	-6.1	72.5	-9.2	68.0	NEW
27.3238	18.1271	14.99	17.74	23.90	21.16	2009.046	-25.2	-91.0	-23.8	-90.0	GWP 225
27.5833	11.7723	14.44	15.12	88.84	45.54	2008.839	-68.1	-102.7	-69.6	-101.4	GWP 227
27.9165	-18.8276	14.06	17.39	191.24	14.37	2004.956	112.1	7.1	116.7	2.8	LDS 1119
28.1953	64.4091	17.69	18.35	39.88	110.74	2005.841	-28.2	73.6	-29.1	74.6	NEW
28.4826	29.5325	17.44	17.79	354.24	13.90	2009.082	135.8	-46.5	137.1	-47.3	AZC 18
29.0487	-3.1614	14.42	14.49	205.49	26.13	2008.831	-11.0	-68.1	-9.0	-68.5	UC 648
29.1263	65.7435	19.70	20.88	154.66	51.12	2005.841	16.3	-61.2	12.8	-61.3	NEW
29.4425	24.6173	15.55	17.60	167.02	7.66	2009.737	-52.7	-69.1	-50.3	-66.1	NEW
29.4645	16.2257	15.72	15.80	90.56	12.21	2008.754	162.8	62.4	159.7	61.7	CBL 11
29.4920	62.3444	16.49	18.83	302.36	117.26	2005.994	-3.2	-114.1	1.3	-113.7	NEW
29.7619	29.6839	16.81	17.19	131.46	9.81	2009.082	25.5	-64.3	25.9	-63.2	AZC 19
30.2393	-5.1792	14.33	17.45	300.98	33.32	2008.997	136.8	-35.2	134.0	-38.7	LDS 5361
30.2677	-17.6834	15.29	17.34	262.33	13.28	2004.956	225.4	6.7	223.3	2.3	LDS 5362
30.4752	67.1517	20.26	20.59	41.74	112.58	2005.994	-22.8	63.3	-19.1	63.1	NEW
30.5441	-18.1415	17.81	18.99	178.72	10.20	2004.956	13.5	-97.9	10.9	-94.7	GWP 252
30.8484	8.8319	16.08	17.61	83.24	22.71	2008.825	-23.5	-65.5	-28.5	-68.1	NEW
30.8662	62.3385	19.17	20.89	228.45	34.86	2005.841	-9.5	86.0	-5.1	87.2	NEW
30.9631	2.6808	15.46	17.55	59.64	13.85	2008.757	53.1	-227.4	52.7	-229.0	LDS 3341
31.6560	-7.1281	14.33	16.50	342.64	23.24	2009.044	130.6	30.8	130.6	30.0	LDS 5366
32.9871	16.9943	15.97	18.21	296.30	23.36	2005.931	137.8	-105.5	138.2	-103.1	LDS 3355
33.1654	16.2350	16.84	17.74	132.17	14.81	2005.844	-27.6	-94.1	-29.4	-90.4	GWP 270
33.3434	31.9227	17.36	17.57	160.78	29.49	2008.820	-62.7	-27.3	-60.5	-24.9	NEW
33.6098	-11.0742	15.25	15.65	261.43	15.52	2008.000	100.6	6.5	101.6	4.4	LDS 5373
34.3465	70.7603	16.11	17.72	148.44	31.64	2005.841	-57.1	71.9	-59.2	70.5	CBL 210

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
35.0575	5.5767	16.19	16.78	97.92	28.51	2005.781	15.0	-71.1	13.9	-68.8	CBL 211
35.8361	22.5007	13.30	17.29	91.02	12.68	2008.752	85.1	-167.3	86.9	-172.1	LDS 3378
35.9285	25.0468	16.44	16.51	180.19	15.73	2009.789	17.1	-127.0	21.0	-129.0	LDS 3379
35.9810	-9.3842	15.03	16.42	217.31	11.90	2000.738	-90.6	-47.8	-94.0	-44.3	LDS 5382
38.1240	6.1042	13.93	17.92	56.12	18.24	2009.710	126.2	-86.3	130.6	-84.4	FMR 55
38.1830	74.1485	17.64	17.82	160.89	14.76	2005.841	209.8	-53.7	205.6	-52.8	CBL 212
38.2552	1.0940	15.02	15.48	344.52	29.12	2008.683	140.9	-44.9	145.7	-44.3	CBL 213
38.8032	21.0488	15.44	16.43	71.56	30.35	2008.752	119.0	-24.6	120.6	-28.4	SLW 120
39.2101	20.2111	14.92	17.58	143.35	19.65	2008.752	97.5	-42.8	95.1	-46.7	SLW 123
40.6041	2.7748	16.28	16.62	290.60	29.70	2008.683	-37.5	-110.8	-37.7	-110.2	GWP 356
42.1294	32.7722	16.75	17.81	272.22	33.62	2005.931	5.4	-60.7	7.3	-62.3	NEW
42.1814	-5.4392	15.42	16.15	106.15	20.22	2009.044	63.2	-12.5	64.1	-11.4	UC 819
42.8408	-15.4281	17.68	17.80	82.09	66.76	2004.956	-47.7	-63.5	-50.3	-65.4	GWP 382
43.9682	-15.3465	16.43	16.46	23.25	18.30	2004.956	155.4	-155.7	156.2	-154.6	LDS 3441
44.6393	6.7659	15.41	17.44	27.58	31.29	2004.953	64.7	-18.7	64.1	-18.3	SLW 140
44.9157	-14.5963	14.30	16.98	336.68	9.81	2004.956	-16.6	-242.7	-19.3	-240.8	LDS 3445
46.6495	0.4298	14.95	15.85	335.84	30.02	2002.832	-39.8	-68.8	-41.4	-66.4	CBL 218
50.0486	77.9747	14.82	15.97	329.84	28.51	2005.994	32.0	-94.0	35.1	-96.0	SLW 152
50.2429	-0.9275	13.44	15.74	280.41	46.41	2004.727	95.6	-25.8	99.9	-24.0	LDS 5420 AB
52.3878	42.8563	17.03	20.11	208.81	119.36	2003.075	40.9	-89.2	36.1	-89.0	NEW
52.7922	42.0576	17.72	17.84	344.65	23.15	2003.075	70.2	-56.8	69.8	-56.5	BVD 189
57.2477	50.0645	18.98	19.17	266.38	21.25	2004.948	61.2	-81.5	66.1	-77.8	NEW
57.3275	-12.0376	20.06	20.33	337.21	113.66	2004.956	8.8	-77.8	4.4	-80.5	NEW
59.0668	52.1353	20.44	20.52	200.87	52.23	2004.948	26.4	76.4	29.4	73.2	NEW
59.3143	-10.9015	16.44	17.56	124.71	17.25	2004.956	-51.2	-65.4	-52.8	-67.1	GWP 536
59.9129	-11.7903	16.40	17.38	116.35	9.24	2004.956	96.0	-31.4	97.2	-33.7	GWP 540
60.3484	1.1136	15.03	17.05	27.12	37.81	2004.727	110.2	-23.3	112.0	-21.7	GWP 542
60.7972	-0.4043	16.20	20.30	82.40	68.40	1998.726	-28.5	-87.1	-32.1	-88.9	NEW
62.5362	-4.2097	17.62	19.14	249.18	22.06	1999.785	56.2	-197.7	54.7	-196.2	NEW
62.5964	16.1847	14.26	17.65	4.31	45.32	2006.084	2.8	-71.5	3.1	-70.8	GWP 557
64.3080	29.2129	15.50	17.08	70.43	11.50	2002.930	66.3	-1.5	65.6	-5.8	NEW
64.4973	52.9498	13.09	19.20	199.02	15.04	2004.790	58.4	-80.0	62.3	-80.0	NEW
64.9543	32.1998	17.92	17.95	349.01	85.47	2002.999	18.5	-82.0	19.7	-85.3	NEW
65.2939	6.4451	16.44	17.18	307.22	30.16	2006.835	49.0	-94.8	50.9	-98.5	SLW 171
65.7116	54.5303	19.64	20.18	170.72	116.23	2004.948	2.5	-73.9	0.4	-74.2	NEW
66.6478	19.1939	15.33	18.39	182.97	37.46	2006.810	153.3	-195.7	151.0	-199.7	GWP 585
67.5064	-1.0774	14.77	18.10	239.13	10.90	1998.884	-10.6	-76.1	-10.7	-80.5	GWP 592
67.5265	9.0411	15.08	15.68	251.98	16.11	2006.835	-33.1	-69.0	-31.1	-70.9	CBL 225
68.2832	-0.7446	15.43	17.07	178.04	10.84	1998.884	40.9	-121.0	42.8	-124.5	GWP 596
69.5509	-7.6016	17.60	18.02	196.07	53.06	2007.102	18.0	-81.0	14.7	-84.3	NEW
71.1993	-0.0085	15.34	15.48	358.17	45.64	1998.879	160.5	-14.7	157.6	-19.6	GWP 611
71.4396	58.0921	20.09	20.67	1.52	82.15	2004.951	-33.4	72.4	-33.6	71.3	NEW
72.0206	59.6764	15.79	15.81	358.24	22.09	2004.790	85.3	-69.6	81.7	-67.4	CBL 226
72.4602	-6.4204	16.59	17.54	336.79	23.87	2007.102	62.7	14.1	62.5	15.8	NEW
72.5439	-4.2093	14.85	15.24	287.93	12.77	2007.883	132.1	-59.5	136.5	-61.3	SLW 172
74.4233	26.1747	13.77	16.12	130.79	63.76	2003.971	66.7	-4.8	71.1	-4.4	LDS 6152
75.9398	-3.2587	17.80	18.35	277.30	87.88	2007.883	7.3	-87.2	3.3	-90.1	SLW 178
77.7073	-2.0041	19.49	20.37	327.37	65.46	2007.883	23.8	-63.2	21.8	-65.5	NEW
80.2154	26.6981	15.89	15.92	174.68	10.33	2006.824	-63.6	24.8	-63.2	20.2	AZC 43
80.7033	28.0082	18.14	20.51	26.64	109.72	2003.971	69.3	-124.4	68.5	-129.2	NEW

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
80.9712	28.4175	12.94	14.81	163.09	44.73	2006.084	-62.9	-101.3	-61.2	-99.8	IPH 13
82.6950	-0.5675	15.26	17.47	283.72	15.11	1998.879	-83.9	-128.8	-83.2	-132.4	CBL 228
82.7899	63.3446	14.94	17.42	71.93	27.13	2004.951	43.7	-111.6	47.3	-114.4	CBL 229
83.2143	3.4040	17.74	21.06	234.45	58.92	2005.189	14.2	-60.4	16.3	-64.7	NEW
83.7654	3.6155	16.36	20.42	68.76	118.99	2005.189	8.7	-65.4	12.9	-64.1	NEW
85.8302	3.5375	18.80	20.09	186.17	109.09	2007.884	8.2	65.6	3.9	66.7	NEW
87.0119	22.0589	19.84	20.05	318.17	87.86	2006.890	28.1	-65.1	23.4	-66.4	NEW
89.5894	22.0736	19.13	20.37	140.32	94.55	2006.887	-10.0	-66.7	-5.6	-69.5	NEW
91.7696	63.4211	18.43	20.04	294.41	18.72	2004.798	1.1	-60.6	0.3	-61.3	NEW
93.2852	5.3769	17.67	18.72	213.90	14.74	2007.102	31.3	-68.0	35.7	-69.9	GWP 764
93.9610	44.4394	18.80	18.93	70.09	15.29	2000.937	7.5	-67.2	4.6	-69.8	NEW
95.0016	34.6970	19.12	19.40	180.95	21.56	2006.827	23.5	-102.6	22.7	-100.6	NEW
97.3074	7.8459	16.84	17.08	193.85	14.01	2007.884	26.8	-78.7	23.1	-83.0	IPH 24
100.1133	64.2539	14.32	16.33	24.76	14.36	2004.951	11.7	-140.2	10.6	-137.6	CBL 233
101.0817	10.3339	15.82	16.36	54.55	14.46	2006.895	-17.6	-109.3	-14.9	-107.1	LDS 5680
105.1090	37.5503	17.36	18.63	188.05	100.24	2006.881	42.5	-92.0	38.3	-93.1	NEW
106.8448	66.2761	16.86	18.99	327.80	84.53	2004.790	-13.2	-68.7	-15.8	-64.0	NEW
107.3515	31.3240	19.34	20.03	251.64	9.34	2006.887	-15.8	-62.0	-16.6	-60.6	NEW
110.4190	35.8510	17.34	19.00	184.78	26.14	2003.812	21.6	-114.4	18.4	-117.3	SLW 192
110.7781	14.1111	17.49	19.16	121.67	9.32	2006.895	6.4	-65.3	3.6	-69.8	GWP 901
111.9617	42.4719	15.41	17.25	172.80	32.09	2003.886	51.6	-145.9	51.4	-145.6	CBL 234
112.0865	31.0035	14.49	17.28	296.16	9.39	2001.071	24.9	-144.5	21.8	-142.9	CBL 235
113.9183	27.8237	14.95	16.22	102.42	17.56	2001.967	-83.8	-53.9	-81.3	-53.4	CBL 236
115.7318	66.4950	15.12	18.55	266.70	65.54	2004.951	-33.1	-87.5	-31.4	-86.6	NEW
115.7945	42.8767	14.24	19.78	233.35	52.72	2000.315	-25.6	-68.3	-23.3	-69.0	NEW
116.0562	37.6648	14.64	17.66	14.79	112.88	2000.258	110.6	-69.9	107.6	-71.4	NEW
116.4990	44.6468	17.44	19.16	227.93	94.28	2003.810	-21.2	-60.3	-21.6	-60.5	NEW
117.8786	-9.2879	14.35	14.76	29.45	15.93	2008.001	-51.7	-175.0	-50.5	-179.6	NEW
118.2084	82.6954	15.16	15.39	167.44	115.48	2005.994	-155.8	34.4	-157.8	36.9	SLW 210
119.1866	46.3326	16.46	16.54	120.72	20.28	2000.263	-0.8	-140.4	-4.2	-140.4	SLW 214
119.7087	46.4449	14.98	16.96	326.97	12.99	2000.315	-87.6	6.0	-87.9	5.0	CBL 238
121.5498	35.7325	15.70	17.90	222.45	14.77	2001.967	-29.5	-63.9	-33.0	-64.9	NEW
121.6154	42.5302	18.23	19.30	180.73	8.03	2001.072	-38.3	-67.2	-34.8	-68.4	SLW 219
121.9631	65.2387	15.72	16.09	4.39	11.14	2004.790	-152.1	-307.5	-150.8	-307.4	LDS 2561
122.3855	54.1074	15.74	18.36	180.52	64.76	2003.913	20.6	-68.3	17.0	-68.4	CBL 244
122.4947	7.9378	14.77	19.70	15.63	10.14	2006.016	-3.2	-65.7	0.1	-66.0	NEW
122.7108	53.6292	16.66	17.87	341.66	113.91	2003.913	-25.5	-68.0	-29.6	-66.8	NEW
123.4082	29.5494	14.63	16.94	72.07	14.20	2002.038	5.2	-69.7	4.8	-70.2	NEW
123.5535	14.1471	15.07	17.74	36.14	22.03	2004.951	-68.8	-69.6	-64.5	-72.5	CBL 245
123.8913	29.8493	15.30	16.07	288.15	17.71	2002.106	48.0	-81.4	43.9	-82.9	SLW 230
124.2610	55.0623	15.87	16.25	109.62	31.02	2003.913	-19.3	-105.5	-21.3	-107.7	SLW 231
124.6412	31.6339	14.63	16.32	106.06	64.47	2002.024	-8.4	-69.7	-9.8	-67.4	NEW
125.1800	-0.0155	17.15	18.19	89.60	55.59	1999.220	-61.5	-71.7	-65.1	-69.1	SLW 241
125.9202	14.5367	14.19	16.71	321.64	28.54	2004.970	32.8	-138.9	34.9	-140.9	LDS 1211
126.0429	-1.8337	13.11	15.91	123.73	42.90	2001.213	-86.6	-5.4	-86.5	-5.6	GWP 1014
126.0723	-4.4038	15.66	17.91	300.71	24.53	2006.881	123.1	-95.4	123.6	-98.3	GWP 1015
126.7865	32.9944	18.14	18.84	334.91	6.50	2002.106	-19.9	-66.4	-21.7	-63.5	NEW
127.0938	0.4361	16.91	17.51	265.20	27.71	2000.173	4.5	-113.6	2.8	-116.8	LDS 3793
127.1317	27.6510	18.61	19.62	206.02	12.80	2002.999	29.6	-115.8	31.2	-120.1	NEW
127.4853	47.1119	15.46	16.85	336.61	23.34	2001.072	-66.8	-12.9	-65.4	-13.6	GRV 1005

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
127.9852	18.5763	14.96	16.91	259.32	11.45	2004.951	-53.6	-100.6	-55.5	-102.4	LDS 1215
128.1922	4.8981	13.67	16.69	219.27	101.15	2002.174	-63.1	-23.6	-62.1	-24.0	GWP 1036
128.4603	20.2201	15.05	17.63	5.56	85.10	2004.948	-69.7	17.6	-72.7	15.5	NEW
128.4661	24.4369	16.97	18.63	69.61	42.67	2003.971	-61.3	120.5	-64.1	118.1	CBL 260
129.4731	31.7043	13.22	18.24	72.84	14.85	2002.851	-79.6	-85.3	-78.8	-88.1	LDS 3802
130.0760	47.6603	18.18	19.03	299.28	64.45	2000.907	-29.6	-66.2	-26.8	-65.5	NEW
130.3365	1.1579	16.25	16.79	342.74	22.72	1999.220	64.9	-126.7	66.1	-125.2	LDS 3807
130.6014	58.4335	15.01	16.78	161.87	61.17	2003.812	-75.5	-37.7	-74.3	-34.5	SLW 282
130.9752	58.4797	15.48	16.40	347.24	23.29	2003.810	-26.6	-74.6	-29.0	-77.3	CBL 266
130.9827	14.2193	17.27	19.77	226.05	47.34	2005.194	-25.8	-66.8	-29.4	-66.2	NEW
131.1456	49.2003	16.02	17.72	210.15	38.77	2001.071	60.9	-4.8	62.0	-3.8	SLW 286
131.2634	14.9010	16.45	19.29	31.28	38.28	2005.841	34.8	-75.1	39.7	-78.7	NEW
131.5521	7.7396	13.70	17.00	3.40	47.85	2003.075	162.3	-103.5	164.0	-104.7	LDS 3817
131.5803	50.3219	14.77	17.59	268.88	17.12	2001.071	-20.5	-89.4	-21.2	-92.7	SLW 290
131.6001	24.0368	16.19	16.73	110.30	22.20	2004.212	-79.0	-73.4	-78.0	-75.0	CBL 267
131.9749	43.0445	13.04	15.81	334.47	95.10	2001.967	2.2	-64.3	5.6	-68.8	NEW
132.2878	56.0776	14.17	18.84	65.14	90.53	2003.062	172.7	-77.2	169.9	-74.3	LDS 3820
132.3778	60.0379	15.50	17.23	105.80	15.00	2003.812	-244.1	-17.0	-243.2	-17.7	LDS 1219
132.6098	42.2155	17.58	19.15	132.98	90.10	2001.967	-14.9	-68.6	-13.6	-65.7	NEW
133.0240	32.7813	15.75	16.81	13.75	12.11	2002.999	-39.6	-87.3	-38.0	-92.2	SLW 308
133.3336	48.6003	17.05	18.63	317.84	9.59	2001.145	-29.7	-81.5	-30.1	-79.6	BVD 203
133.4041	55.5337	16.54	16.69	270.22	14.97	2003.062	67.3	-32.4	68.1	-33.4	GRV 1012
134.6606	4.4862	16.71	16.94	59.24	33.38	2002.120	11.8	-66.8	9.6	-64.1	SLW 318
134.9539	18.5543	19.40	20.36	252.96	39.17	2004.971	-8.8	-61.4	-5.2	-60.1	NEW
135.9097	44.9843	13.45	16.73	291.37	17.34	2002.024	60.1	-49.6	60.3	-46.7	BVD 206
136.5376	12.3807	15.10	15.73	96.18	18.97	2006.016	-11.0	-65.1	-12.9	-68.8	GWP 1136
137.9730	64.5921	14.55	16.88	303.62	105.96	2003.886	67.4	-6.7	67.2	-7.2	NEW
138.0561	28.6351	17.98	18.87	295.66	36.81	2004.209	-17.8	-74.3	-18.8	-77.9	CBL 274
139.0599	6.1589	15.54	16.71	8.59	106.30	2002.120	35.6	-149.2	32.8	-152.4	SLW 339
139.4385	53.2153	13.57	17.44	226.47	26.15	2000.907	143.2	-31.5	146.0	-32.5	LDS 3869
139.6849	17.1915	18.46	18.77	333.77	8.98	2005.194	-44.2	-93.2	-48.1	-93.4	NEW
140.3947	26.9298	14.40	14.42	59.95	29.64	2004.288	45.4	-61.4	46.2	-63.2	AZC 62
140.5475	34.0574	14.94	14.95	76.80	13.61	2003.086	55.9	-81.4	52.7	-80.2	CRB 81
141.2885	36.7066	12.81	15.97	273.56	15.35	2003.067	-73.0	-47.5	-72.1	-48.2	CRB 82
141.6457	45.7897	13.01	16.45	259.11	13.38	2001.890	3.8	-72.9	3.7	-73.0	CBL 278
141.9756	28.6393	14.18	16.25	115.43	45.78	2004.212	-103.1	-49.8	-105.5	-52.1	CBL 279
142.6479	55.9815	18.15	20.06	190.03	13.46	2001.071	-18.8	-61.1	-20.8	-60.4	NEW
143.1430	55.1921	17.96	18.14	207.74	7.91	2001.071	-53.5	-61.8	-56.1	-65.6	CRB 181
143.6459	15.2116	16.84	17.16	302.67	31.71	2005.356	24.1	-62.4	27.4	-60.6	SLW 369
143.8819	15.2363	16.82	17.06	85.45	15.99	2005.356	-119.7	4.9	-121.3	1.3	CBL 285
144.8106	30.2452	14.75	18.10	107.10	72.61	2004.212	55.6	-138.2	52.3	-141.8	LDS 3909
145.1421	59.2459	15.26	16.72	295.44	29.28	2000.258	-242.5	-93.2	-244.4	-91.5	LDS 1230
145.2355	46.1250	16.85	17.55	248.03	49.36	2001.970	-97.2	41.0	-94.6	38.6	NEW
145.3156	7.1286	15.49	16.14	244.94	22.72	2002.934	-64.7	-158.0	-61.5	-158.1	GWP 1212
146.2065	-2.9304	12.16	15.25	162.87	120.00	2001.213	-91.1	-2.5	-90.1	-5.6	GWP 1229
146.3416	46.2759	16.63	17.06	21.80	21.73	2002.024	-195.0	-132.1	-194.3	-133.2	LDS 3922
146.3549	3.7221	16.18	18.67	253.67	29.40	2001.140	-35.0	-92.6	-37.8	-97.0	GWP 1232
147.0062	81.6037	14.76	18.97	147.48	17.27	2005.994	-85.0	-73.2	-86.9	-78.0	NEW
147.2835	-0.8997	15.23	17.45	333.64	9.67	1999.220	-71.7	44.2	-75.5	47.7	NEW
147.3219	4.0710	17.66	17.76	220.91	29.85	2001.140	-75.5	-14.5	-73.1	-16.7	SLW 394

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
147.3345	20.7109	15.73	16.08	258.74	16.05	2005.096	-85.4	30.9	-84.1	28.8	LDS 3932
147.6203	22.3703	16.20	16.23	25.81	15.57	2005.047	18.5	-68.7	19.4	-68.0	AZC 63
147.6889	24.1602	16.66	18.82	107.13	53.72	2004.957	19.7	-61.3	22.2	-61.3	NEW
148.2477	58.1898	18.02	18.59	278.29	7.63	2001.071	9.8	-61.3	13.8	-63.4	NEW
148.8217	22.0523	18.49	18.60	65.50	7.24	2004.971	50.1	-85.2	52.5	-86.1	NEW
149.0813	27.9690	15.28	15.69	84.94	60.32	2004.367	-75.7	11.1	-76.7	12.1	UC 1845
149.1125	-1.9132	14.51	17.00	164.23	14.05	2000.173	-99.8	-84.4	-100.6	-84.5	LDS 3944
149.4029	0.4876	14.87	17.87	190.58	40.86	2001.145	-82.7	-18.8	-81.5	-16.0	NEW
149.4194	-1.1783	15.55	17.67	265.01	17.07	2001.145	-65.6	-5.7	-64.4	-7.3	NEW
149.6509	11.8978	15.12	16.72	293.43	27.10	2003.971	-62.3	12.8	-61.7	12.5	GWP 1263
150.4355	51.5774	14.38	17.15	132.42	10.14	2002.024	-70.5	13.0	-70.8	10.1	NEW
150.6464	34.9509	16.26	19.45	282.00	7.57	2004.130	-29.4	-78.1	-30.7	-77.8	NEW
150.9852	2.1271	15.60	15.83	325.36	20.50	2000.343	-75.8	23.1	-75.8	24.6	GRV 1042
151.0052	19.1477	15.42	15.96	307.28	110.34	2005.194	64.7	-16.4	66.6	-18.6	NEW
151.0743	47.5310	15.64	17.69	334.91	26.42	2002.035	-78.1	10.8	-76.1	6.2	CBL 299
151.1729	43.0043	15.65	17.33	115.05	11.03	2002.950	59.8	-100.6	60.7	-95.8	LDS 3953
151.9045	54.2666	13.79	15.99	0.14	45.47	2002.120	-63.2	-29.9	-64.4	-30.1	AZC 160
151.9573	21.8394	16.44	17.51	24.78	28.29	2005.096	-68.1	-3.8	-67.4	-5.8	NEW
152.1531	38.3227	16.27	16.58	44.34	12.44	2003.087	35.7	-62.8	36.8	-61.7	SLW 438
152.3194	11.3648	17.48	18.43	63.83	16.53	2003.075	-4.0	-60.7	-8.4	-61.0	GWP 1303
152.4093	40.6873	16.17	16.43	203.84	35.29	2002.999	-59.5	-73.1	-63.4	-72.2	CBL 301
152.8377	27.3593	16.22	17.37	69.76	13.80	2004.367	-171.0	-301.7	-172.3	-302.4	LDS 3961
153.1661	66.1619	17.90	18.24	244.90	90.91	2003.812	-31.7	-64.6	-36.1	-60.9	NEW
153.6331	1.8860	14.85	16.60	225.95	21.25	2000.343	-131.5	-50.2	-127.0	-53.8	CBL 306
153.8398	47.4380	13.29	13.51	232.52	47.84	2002.035	-74.0	-122.4	-70.8	-122.0	UC 153
153.9910	11.3786	17.26	18.30	211.96	9.62	2002.953	4.0	-67.8	-0.5	-64.7	GWP 1333
154.1745	38.9387	15.49	16.20	155.74	18.65	2003.087	-141.7	1.0	-138.9	1.6	LDS 3971
154.8019	13.3222	15.15	15.70	207.23	83.04	2003.971	-65.4	-4.9	-62.8	-6.8	GWP 1345
155.3613	25.6480	18.61	20.55	317.24	71.64	2004.957	8.6	-64.3	8.3	-66.9	NEW
155.4594	35.9173	16.23	17.55	144.51	13.23	2004.130	-162.5	-81.4	-162.9	-82.2	LDS 1240
155.5374	34.4506	17.06	17.50	70.56	28.14	2004.212	-65.2	-29.4	-63.1	-30.4	CBL 307
155.6880	58.5974	15.93	16.33	37.50	9.11	2001.378	-5.6	-66.8	-2.8	-64.7	SLW 9001
156.6538	62.7551	17.37	17.42	312.79	9.74	2001.072	63.2	-38.6	60.8	-41.1	LDS 2583
156.7203	45.1841	17.65	18.56	323.78	8.52	2002.219	-72.1	-69.2	-76.1	-67.1	SLW 473
157.6359	31.4971	17.11	17.86	254.67	17.29	2004.291	-65.8	-15.3	-68.2	-13.2	NEW
158.3636	17.9975	18.64	20.20	87.75	48.16	2005.356	86.6	-126.4	82.1	-131.3	NEW
158.5637	40.6830	15.47	16.11	220.43	104.19	2003.087	-214.1	-108.0	-213.5	-110.6	LDS 3998
159.0221	29.1049	15.45	15.62	271.20	16.31	2004.970	-91.8	-48.5	-91.9	-48.3	LDS 1248
159.1624	54.6806	14.74	18.81	311.23	9.17	2001.967	-90.7	-77.0	-86.8	-78.6	LDS 2870
159.2800	51.3378	13.78	16.13	10.12	41.28	2002.248	-26.7	-153.9	-26.5	-155.4	LDS 2871
159.5184	24.6950	15.43	16.70	44.60	67.55	2005.047	-85.7	-69.7	-82.2	-71.1	SLW 500
159.6264	12.1666	16.15	19.08	244.84	117.56	2003.245	-102.2	-67.4	-101.9	-63.8	GWP 1417
159.7034	6.0255	13.93	16.84	39.91	46.24	2002.120	-116.1	-10.9	-118.8	-8.9	LDS 2875
159.9180	32.4518	12.64	14.78	316.75	48.60	2004.291	108.5	-160.3	111.6	-160.9	DAM 28
160.3248	21.9051	16.28	16.72	8.34	24.14	2005.096	-71.6	-48.4	-73.0	-50.3	AZC 65
161.1572	65.8421	18.60	19.97	256.17	103.12	2000.264	-57.7	-98.0	-58.5	-93.3	NEW
161.2427	61.2439	14.07	17.24	173.15	53.89	2001.378	-103.0	-35.7	-106.0	-35.0	LDS 2586
161.8387	33.8267	16.22	18.46	334.45	24.54	2004.291	44.8	-63.4	47.6	-65.9	CRB 85
162.2172	-1.0379	16.95	17.31	61.28	11.27	1999.221	-60.2	8.5	-63.0	9.1	GWP 1465
162.5800	-22.5686	16.33	16.72	59.42	10.50	2006.079	-98.1	-1.8	-94.8	-5.6	LDS 4024

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
162.7791	24.5540	18.02	20.28	246.53	95.78	2005.096	-4.5	-61.1	-4.2	-63.7	NEW
162.8541	-20.8813	16.50	17.17	156.88	13.41	2006.019	90.1	-115.8	88.4	-114.4	NEW
163.2244	23.0184	17.48	17.91	0.27	28.73	2005.096	-77.6	-28.7	-78.6	-30.1	NEW
163.5905	26.9390	16.87	18.19	211.03	65.18	2005.047	2.3	-94.1	5.8	-92.1	SLW 538
164.1451	58.9921	16.60	17.68	262.39	17.00	2002.120	-34.5	-115.5	-36.6	-111.1	LDS 2589
164.4492	-1.1188	15.41	17.08	185.68	50.64	2007.300	-77.6	15.0	-77.9	13.7	GWP 1509
164.4949	10.0343	16.42	19.80	254.17	72.00	2006.393	-120.2	-111.6	-118.4	-113.5	NEW
164.9008	12.6671	14.42	16.78	146.33	19.40	2002.953	-318.5	-106.0	-316.2	-106.7	LDS 4043
164.9447	22.7130	17.46	17.76	352.33	25.12	2005.096	34.3	-95.9	35.6	-93.0	CBL 324
164.9983	13.7466	15.58	18.89	13.46	31.22	2003.076	83.5	-79.4	82.8	-79.0	GWP 1516
165.0335	75.7973	16.35	17.23	121.93	67.28	2006.303	-74.5	-2.5	-72.1	-1.9	NEW
165.1309	64.2894	15.32	16.23	66.92	28.40	2001.072	-98.3	-46.7	-97.9	-47.2	GRV 1050
165.5079	23.8855	14.69	16.12	118.96	97.80	2005.096	-145.9	-96.0	-145.6	-91.4	CBL 326
165.5557	46.0724	15.58	16.35	66.18	10.48	2002.950	-71.9	-19.5	-69.2	-20.1	SLW 555
165.7347	55.4758	13.93	16.19	347.25	107.21	2001.967	-98.1	-6.9	-98.8	-11.0	NEW
166.1409	63.0615	16.22	18.43	95.28	25.74	2001.072	26.0	-89.0	25.7	-88.8	BVD 317
166.5567	47.4351	15.16	16.47	146.51	12.88	2002.106	65.0	-40.5	67.4	-40.7	GRV 1192
166.8162	31.7627	16.32	17.50	161.16	15.04	2004.362	37.6	-76.0	33.9	-72.0	NEW
167.0888	47.8605	13.43	15.75	222.77	22.97	2002.219	-119.1	-170.3	-116.7	-166.3	BVD 216
167.3230	54.3821	17.94	18.00	20.34	9.94	2001.964	-5.0	-61.1	-3.2	-61.9	NEW
167.4628	47.6190	13.62	17.82	301.76	10.53	2002.106	-109.3	-9.1	-112.1	-5.6	CBL 330
167.4965	-2.8093	14.92	16.05	165.39	49.41	2000.116	-81.7	-53.3	-81.6	-56.1	UC 2092
167.9294	58.0516	15.81	16.13	25.79	14.93	2001.287	-10.0	-63.8	-13.7	-63.3	UC 2097
167.9491	32.2973	18.00	20.28	139.09	93.94	2004.362	-67.0	-81.3	-66.3	-80.1	NEW
168.7687	23.7046	15.63	15.66	103.85	42.30	2005.252	-73.2	-111.7	-72.5	-113.3	AZC 69
168.8277	18.8524	16.58	17.71	131.75	12.36	2005.356	-73.8	-6.5	-71.7	-7.0	GWP 1564
168.9197	59.3823	16.87	16.88	316.93	8.84	2002.120	-88.4	-18.2	-88.1	-14.9	SLW 582
168.9293	0.7805	14.87	16.21	155.68	19.52	1999.221	-86.0	-10.8	-84.0	-10.8	GWP 1567
169.8378	23.6848	15.98	16.48	353.46	13.82	2005.096	-81.8	-23.3	-83.5	-23.8	AZC 70
170.0507	25.4726	15.32	15.97	116.30	21.60	2005.096	-19.8	-113.2	-20.0	-110.4	CBL 337
170.0734	7.1150	16.48	17.17	20.29	29.59	2002.175	-66.3	-17.2	-63.1	-20.5	NEW
171.1441	20.4038	17.01	19.02	32.96	12.96	2005.356	41.9	-78.0	42.5	-78.1	NEW
171.1513	34.9757	13.61	15.64	353.77	29.79	2004.283	-134.6	-13.8	-136.5	-15.6	LDS 4095
171.3307	74.5472	15.42	16.60	130.03	11.87	2006.303	62.6	-97.4	61.7	-99.3	SLW 599
171.6865	25.0545	16.95	17.13	355.28	12.35	2005.096	-80.7	-37.4	-78.8	-38.5	CBL 340
172.3154	39.5277	15.92	18.04	275.86	14.74	2004.130	82.3	-145.6	84.8	-142.5	SLW 607
173.3764	33.1415	12.50	16.19	211.26	56.86	2004.367	-109.8	-9.1	-107.9	-13.0	CBL 344
173.4052	7.6400	19.31	20.55	14.67	111.55	2002.175	-33.5	-110.8	-33.2	-114.6	NEW
173.4548	14.5576	17.78	18.63	134.87	70.10	2004.075	-29.4	-75.7	-31.4	-73.5	GWP 1609
174.2693	39.7942	16.27	17.00	147.44	23.22	2004.130	-80.7	-0.3	-80.7	-4.4	NEW
174.5784	61.2106	15.83	16.01	216.00	19.87	2001.378	-91.4	-90.9	-92.0	-89.7	LDS 2605
174.7520	4.1059	15.36	15.52	0.29	10.87	2001.290	-92.7	25.5	-94.5	28.7	GRV 1059
174.9084	21.0792	17.49	17.59	93.52	13.65	2005.195	75.2	-77.9	72.7	-78.2	NEW
175.8591	9.6778	15.44	17.86	331.80	9.63	2002.945	-83.2	-18.8	-81.3	-17.5	SLW 636
175.9255	54.9623	15.20	16.98	175.93	29.45	2001.964	-91.2	23.9	-91.1	22.1	CBL 350
176.5905	30.9614	15.19	15.43	2.07	21.72	2004.957	-160.1	84.3	-158.2	84.6	SLW 645
176.7381	20.9385	14.62	14.67	261.60	25.31	2005.252	-83.5	-12.8	-80.4	-8.2	CBL 357
177.4709	5.2841	16.25	20.04	166.94	56.31	2001.140	-35.1	-60.7	-31.3	-62.8	NEW
178.0810	38.4354	16.82	17.23	78.14	24.84	2004.207	-101.1	-11.8	-100.2	-11.9	LDS 4151
179.4062	64.1585	14.57	16.93	55.94	66.32	2001.072	-71.8	-5.4	-70.0	-7.9	NEW

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
179.4238	43.3370	14.93	15.63	27.50	45.95	2003.248	-60.6	-20.3	-61.2	-19.6	BVD 219
179.9736	11.7341	14.80	15.18	336.68	55.60	2003.223	79.0	-28.5	76.8	-27.1	BPM 585
180.0686	6.2962	16.30	17.29	121.35	19.11	2006.019	89.0	-55.3	88.3	-55.5	GRV 1196
180.3611	2.0520	20.47	20.75	60.07	73.04	2000.340	12.7	-65.0	8.0	-68.7	NEW
180.5532	24.0432	16.68	17.96	227.65	10.35	2005.050	-96.6	-43.0	-94.5	-39.2	SLW 678
180.6561	44.2993	16.36	18.71	239.26	12.87	2003.226	-164.5	-66.0	-162.1	-66.7	BVD 221
180.7327	0.0682	14.70	16.46	99.12	12.08	2007.300	-73.8	48.2	-69.8	48.1	GRV 1068
181.0907	63.0134	15.28	17.80	186.39	91.45	2001.391	-103.6	-41.6	-102.4	-40.2	CBL 371
181.2457	21.8241	14.50	14.81	336.27	77.36	2005.195	-183.0	-84.5	-182.9	-83.1	LDS 4177
181.7197	39.3493	15.25	15.37	19.49	8.34	2004.130	-61.8	49.5	-62.4	49.5	SLW 684
181.9031	15.5508	14.95	15.62	104.50	14.55	2003.076	-92.7	-37.6	-92.8	-38.6	LDS 4181
182.2479	3.9486	17.04	18.81	193.74	18.53	2001.140	1.0	-62.5	-1.4	-66.2	NEW
182.8738	47.4208	14.54	17.85	65.17	30.96	2003.191	-23.9	-323.3	-23.6	-323.5	LDS 4187
183.0093	38.8194	14.17	17.99	9.46	18.54	2003.316	-135.4	-26.4	-134.3	-26.6	LDS 4188
183.6073	27.4000	15.33	16.16	333.00	28.26	2005.050	-112.9	21.6	-113.6	17.8	LDS 1286
183.7332	58.4954	15.50	18.35	155.78	13.13	2002.219	90.6	-102.9	88.7	-105.4	NEW
183.7632	39.2404	14.21	18.95	48.87	32.46	2003.316	-178.1	-113.6	-180.7	-111.9	LDS 4196
183.7653	48.9629	17.37	17.86	20.79	10.68	2002.106	-66.9	21.8	-69.2	21.5	SLW 697
184.4923	27.8577	11.99	16.99	330.58	37.01	2005.050	-81.3	20.4	-81.3	16.4	CBL 378
184.9587	34.5398	17.13	17.67	64.63	109.02	2004.283	68.1	-45.6	68.3	-44.6	SLW 708
184.9656	0.0874	14.56	15.74	137.92	14.95	1999.218	44.0	-64.9	42.1	-67.7	GRV 1075
185.8189	66.7608	15.03	17.41	313.05	33.43	2000.264	-84.2	-50.2	-83.5	-49.0	CBL 381
185.9511	-1.9375	16.20	17.81	169.63	39.80	2000.171	-99.5	-6.5	-97.7	-5.5	SLW 714
186.3220	49.6331	14.80	17.73	343.04	21.93	2002.219	-60.8	-4.9	-61.5	-6.4	NEW
186.6484	38.9523	16.14	16.39	74.90	19.33	2004.130	-88.7	-235.3	-93.2	-235.3	LDS 4208
188.0576	41.0457	12.93	13.89	146.75	112.09	2004.130	-130.0	35.2	-128.1	31.4	UC 177
188.2814	36.2395	15.08	15.53	247.71	13.71	2004.130	69.2	-69.4	67.2	-68.8	CRB 92
188.3522	14.2633	13.67	16.03	262.78	35.09	2003.076	-107.1	-107.7	-108.4	-110.3	LDS 1319
188.5666	0.8583	16.28	16.97	166.89	12.02	1999.218	15.3	-62.6	17.0	-62.2	SLW 736
188.6668	19.8581	15.07	15.34	178.59	60.82	2005.252	73.7	-33.9	76.3	-32.2	NEW
188.7742	1.0875	18.89	19.90	226.03	105.28	1999.221	11.4	-62.2	12.4	-67.1	NEW
188.8861	17.8713	15.57	17.59	325.87	22.91	2005.430	75.5	-57.1	73.7	-59.0	CBL 387
189.0135	62.4957	15.70	18.15	302.83	16.44	2001.391	4.0	-98.6	7.5	-97.3	LDS 2654
189.0556	14.9546	15.21	17.14	14.20	80.53	2004.075	-157.3	-107.0	-156.3	-106.3	CBL 388
189.0842	11.5046	17.28	17.96	35.45	8.60	2002.224	-202.2	-25.3	-204.2	-28.4	LDS 1327
189.1800	1.8364	16.23	16.35	297.57	14.34	2000.343	-36.5	-80.9	-34.3	-82.2	SLW 744
189.3303	-0.2514	17.37	18.85	129.66	15.15	1999.218	-88.3	-60.4	-86.0	-60.6	SLW 747
190.0970	-17.0777	13.93	17.38	173.46	25.97	2006.085	-72.0	-1.2	-71.8	-0.5	NEW
190.1489	22.3836	14.81	17.14	253.26	116.66	2005.189	-116.5	-26.6	-119.0	-22.9	LDS 4246
190.1797	46.4487	16.44	18.37	257.23	11.51	2003.191	-25.9	-75.7	-30.0	-77.8	CBL 391
190.4392	21.5289	15.45	17.71	183.42	25.76	2005.189	17.9	-62.3	20.6	-64.0	SLW 760
190.5172	52.4632	16.41	17.47	8.31	13.81	2001.970	-144.9	-31.6	-145.9	-34.3	LDS 3055
191.3313	3.3217	16.03	18.51	240.05	22.99	2006.331	-19.5	70.8	-23.2	67.0	NEW
191.4615	63.3324	16.49	16.77	143.98	15.07	2001.391	-147.7	81.9	-151.1	82.7	LDS 2658
192.0367	22.0701	15.03	19.27	328.76	28.33	2005.195	-76.8	-85.6	-75.2	-89.0	AZC 77
192.4695	26.7179	16.13	17.63	281.49	15.08	2005.050	-69.0	15.2	-66.3	18.2	LDS 4280
193.0343	37.9245	14.98	16.95	206.93	16.66	2004.207	-124.8	8.8	-125.8	12.1	SLW 786
193.5231	55.0090	16.73	16.78	98.41	10.80	2002.287	-108.3	-10.7	-111.8	-14.6	LDS 3067
193.9053	6.3477	16.09	16.53	285.98	37.79	2003.248	-140.5	36.5	-141.2	34.0	LDS 4295
194.1641	31.0447	16.13	17.80	192.88	35.40	2004.362	51.2	-84.5	50.6	-82.9	CBL 401

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
194.2971	1.6815	13.77	16.16	348.80	26.11	2000.343	15.1	64.2	18.3	64.7	GRV 1200
194.3340	30.7575	16.17	16.88	110.28	79.37	2004.957	-211.1	47.6	-211.2	45.0	LDS 1347
195.1255	28.9943	14.73	15.46	310.23	35.12	2004.390	-64.7	-26.5	-69.3	-24.4	NEW
195.1312	46.1346	15.04	17.47	20.95	23.24	2003.191	-100.6	50.6	-103.3	47.1	LDS 4305
195.8438	43.5609	17.97	18.56	47.46	8.54	2003.226	-27.9	-63.0	-25.5	-64.6	SLW 817
195.9583	32.1669	15.26	15.56	232.80	9.82	2004.362	-2.8	-63.9	-4.7	-65.5	NEW
195.9959	22.8214	17.49	17.51	196.13	53.95	2005.189	-100.8	9.4	-101.8	4.7	NEW
196.3467	12.0039	17.08	17.34	170.91	63.51	2003.223	-217.8	-21.6	-215.2	-24.9	LDS 4313
196.8016	44.5019	15.28	16.36	222.42	54.79	2003.232	-137.2	-18.5	-135.8	-14.1	LDS 4317
197.0658	8.2130	16.79	17.61	329.73	11.82	2003.248	-17.4	-84.8	-18.2	-87.4	CBL 408
197.1407	14.4086	16.86	17.11	228.82	49.84	2003.409	-93.2	-16.6	-94.5	-14.0	LDS 4320
197.5889	32.8829	13.80	16.61	359.92	66.43	2004.362	-174.2	0.4	-178.2	-0.9	CBL 410
197.6643	7.2391	15.02	15.40	301.59	23.34	2003.248	-77.2	-59.6	-81.3	-63.5	CBL 411
197.7023	47.0355	16.29	17.48	109.59	13.89	2003.191	15.4	-76.6	14.3	-76.5	BVD 227
198.3784	16.9411	16.71	17.00	76.52	55.96	2005.430	-82.7	5.0	-82.6	6.7	SLW 837
198.9568	36.1892	14.40	14.68	279.28	39.67	2004.209	-123.7	-119.0	-124.8	-115.7	NEW
199.1036	43.0946	15.14	15.69	133.53	49.30	2003.226	-67.2	-23.8	-65.1	-21.7	UC 2509
199.3243	21.2879	16.21	17.82	179.77	9.00	2005.189	-79.6	15.3	-80.8	16.6	LDS 2910
199.4381	51.5277	14.49	17.70	252.41	89.83	2003.324	-78.4	-25.2	-77.7	-25.6	NEW
199.5646	47.5082	15.19	17.41	355.61	64.52	2003.177	-104.8	31.9	-103.7	33.6	SLW 850
199.7980	10.3285	16.29	16.43	106.03	22.76	2003.319	-66.1	-1.1	-68.6	-2.1	NEW
199.9135	28.3727	14.71	15.05	193.32	27.40	2004.392	-111.7	-79.2	-113.9	-80.8	LDS 1383
200.0329	61.0578	14.57	17.36	153.01	11.74	2001.378	-44.5	-146.3	-41.1	-150.8	LDS 2673
200.0973	6.8900	19.59	19.85	319.16	110.54	2003.248	-22.6	-69.7	-24.8	-69.2	NEW
200.1704	-3.4412	16.10	17.22	343.15	102.78	2001.394	-75.3	-8.9	-79.4	-4.6	NEW
200.2492	43.4603	16.01	16.57	35.54	31.00	2003.226	-66.6	-15.0	-69.6	-11.9	SLW 859
200.5319	67.8116	15.59	16.03	8.08	28.23	2000.264	-52.2	83.3	-49.5	84.3	GRV 1087
200.5657	5.5216	14.58	17.11	236.54	46.92	2001.214	26.5	-137.1	25.8	-136.4	CBL 422
200.6474	16.7131	17.70	17.76	165.04	14.34	2005.430	-71.7	40.7	-75.0	45.2	NEW
200.7787	50.5509	17.22	17.50	231.04	13.16	2003.324	-72.4	-0.5	-69.8	-3.7	SLW 864
200.9903	35.8226	18.81	18.94	179.46	68.06	2004.209	18.0	-80.7	17.3	-85.2	NEW
201.1590	-1.8925	14.68	16.39	230.28	34.80	2001.394	-159.1	-151.7	-156.6	-156.1	LDS 4357
201.2742	51.8829	16.65	17.39	88.31	36.52	2003.246	-8.2	-128.3	-8.4	-125.9	SLW 866
201.3889	22.8945	15.89	16.28	324.49	21.98	2005.252	55.2	-86.9	57.9	-89.1	SLW 867
201.4041	43.7438	15.87	16.27	165.70	9.69	2003.226	-5.4	-77.0	-4.2	-81.0	CBL 425
202.0177	28.1319	14.66	16.99	70.58	28.20	2004.392	-150.0	32.7	-149.7	35.2	LDS 1389
202.4715	26.7921	18.22	18.47	127.47	23.70	2004.447	48.1	-65.3	48.8	-65.4	AZC 79
202.5916	38.7492	14.71	16.89	181.45	38.28	2003.316	-25.0	-62.4	-24.7	-63.1	CRB 98
203.0408	7.7375	15.35	17.68	281.89	18.92	2006.396	-69.8	29.1	-74.7	31.0	LDS 3074
203.2673	38.2188	15.10	17.74	233.12	9.11	2003.316	-45.2	-67.4	-49.6	-64.8	CBL 427
203.4448	19.2795	16.08	17.54	108.07	54.91	2005.353	-95.4	64.1	-99.5	64.2	SLW 892
203.5417	67.2625	17.48	18.78	260.79	16.67	2000.321	31.8	-79.8	35.3	-78.8	LDS 2323
204.0681	33.7085	14.77	16.10	321.02	42.24	2004.291	-161.0	-57.4	-161.2	-55.9	LDS 4380
204.2369	7.8653	14.51	16.85	50.69	65.73	2003.319	-235.6	44.1	-234.5	46.8	VBS 23
204.6930	1.7806	14.19	19.80	180.77	11.47	2006.399	-237.3	-92.0	-234.3	-88.7	NEW
205.1350	33.2328	17.23	18.65	297.47	31.75	2004.283	-41.3	-105.3	-37.0	-107.6	NEW
205.5331	67.3888	16.09	18.17	228.83	11.25	2000.321	-104.2	77.4	-104.3	74.5	LDS 2325
205.6732	21.6020	18.24	19.07	204.35	27.23	2005.189	-38.7	-91.8	-36.9	-88.7	NEW
206.3581	28.9566	14.59	16.20	89.28	20.33	2004.390	-81.3	31.4	-84.1	31.4	LAW 20
206.6125	38.7296	17.81	18.88	1.81	41.60	2004.075	-95.5	-84.7	-92.5	-86.3	SLW 927

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
206.7724	5.9257	16.21	16.22	178.80	37.24	2003.319	-5.3	-64.3	-3.3	-65.0	LDS 3102
206.9649	40.3297	19.49	19.82	71.45	54.91	2003.313	56.0	-89.0	51.4	-87.3	NEW
207.0033	33.7421	14.80	16.11	189.46	69.16	2004.283	78.0	-135.1	79.0	-134.6	LDS 4408 AB
207.1643	29.0224	14.24	16.23	56.93	14.50	2004.392	-145.3	43.6	-140.9	40.3	AZC 80
207.6703	-1.0116	17.12	18.18	99.16	23.65	2006.399	-21.5	-67.4	-18.1	-67.2	NEW
208.2497	7.2811	13.46	19.35	75.03	25.74	2003.319	-30.3	-81.0	-28.0	-85.8	NEW
208.5162	16.5197	15.23	16.61	8.77	36.23	2005.359	-73.2	-28.4	-72.2	-26.5	CBL 433
208.7155	51.4710	14.45	17.44	333.53	10.32	2002.248	-67.1	-44.4	-68.0	-41.8	CBL 434
209.2614	34.0585	17.84	17.90	89.06	81.06	2004.209	-69.4	10.3	-72.7	5.4	NEW
209.3122	19.8819	15.43	16.53	211.63	13.88	2005.195	-75.5	-49.5	-73.7	-46.6	SLW 948
209.4516	24.7934	16.29	16.76	147.51	36.46	2004.447	-75.7	23.6	-76.5	23.8	CBL 435
209.7437	5.5149	15.76	16.05	280.97	49.40	2001.290	-106.7	-55.7	-106.2	-56.4	SLW 953
209.8168	8.0023	17.43	20.63	192.19	84.23	2003.322	-9.8	-64.6	-6.6	-63.9	NEW
210.4113	59.2369	16.49	16.58	48.14	32.11	2001.391	-64.2	27.7	-63.6	27.6	LDS 2697
210.7794	24.3858	16.55	18.09	37.66	10.19	2004.450	-70.0	-76.0	-70.9	-72.4	SLW 958
211.4265	15.6192	14.87	15.13	339.79	48.85	2005.359	-48.7	-65.3	-48.8	-67.8	BPM 613
211.6036	11.6077	16.61	17.96	94.79	14.83	2003.245	-158.5	39.8	-159.1	38.1	LDS 4432
211.8991	53.3696	15.28	17.60	248.34	40.24	2003.180	-154.5	62.2	-152.9	63.4	LDS 2922
212.0121	-16.0398	14.73	16.99	233.86	39.68	2006.396	-65.0	-11.6	-64.3	-15.3	NEW
213.4627	29.4634	16.98	17.41	2.22	102.42	2004.362	36.7	-68.4	32.1	-68.3	SLW 982
213.6376	-1.2288	14.09	15.22	232.97	26.64	1999.218	-68.6	-7.9	-69.0	-8.9	UC 2711
213.7498	2.3744	14.04	17.04	299.16	26.35	2000.343	-94.4	29.5	-95.6	30.4	GRV 1096
213.8628	25.1775	15.77	17.67	312.05	26.19	2004.447	-7.0	-67.5	-7.2	-67.3	NEW
213.8946	48.1117	13.95	16.13	163.61	40.35	2003.324	-77.6	-12.1	-78.9	-9.8	CBL 445
213.9989	5.5835	16.65	16.85	70.73	12.42	2003.319	-64.9	-15.9	-64.1	-12.7	NEW
214.2937	16.7649	16.57	17.88	159.29	21.35	2005.356	-101.9	38.0	-103.1	34.7	SLW 988
214.3429	13.5011	15.68	15.99	55.20	10.52	2003.472	-82.3	33.4	-84.6	32.1	LDS 4452
214.9838	16.5603	14.54	15.50	267.34	63.24	2005.353	-82.8	23.4	-87.5	21.7	CBL 450
215.1114	35.3920	17.30	17.85	23.51	113.92	2003.475	-60.0	-12.4	-60.8	-10.4	NEW
215.7237	-20.6428	16.93	17.33	204.12	89.34	2006.396	-66.6	-60.4	-65.4	-60.1	NEW
215.7887	22.7211	15.59	16.93	295.72	32.57	2005.252	-102.0	-166.6	-102.2	-163.7	LDS 4462
216.1134	59.2281	16.17	16.59	72.95	88.73	2001.392	-87.0	72.1	-89.7	69.7	NEW
216.1498	18.0704	15.88	18.11	224.82	33.32	2005.354	-155.4	-72.6	-153.4	-73.3	CBL 453
216.2367	57.8993	17.14	19.23	325.78	29.51	2001.392	58.3	-74.0	59.6	-74.7	NEW
216.7367	55.6577	16.95	16.98	159.60	14.53	2002.437	-83.2	22.1	-84.8	25.0	CBL 454
216.8442	3.2304	15.49	16.13	126.74	17.13	2000.341	-81.0	4.5	-82.1	3.3	SLW 9005
216.9200	26.2263	16.48	16.85	244.87	8.79	2004.392	-103.4	102.0	-107.7	99.2	AZC 85
217.0552	10.2225	16.01	17.35	205.45	19.54	2003.314	-80.0	-27.3	-79.0	-22.5	CBL 455
217.0786	54.7091	15.08	17.76	89.69	49.42	2002.437	-101.5	36.2	-100.4	37.9	LDS 4468
217.4426	34.7590	15.78	16.38	320.19	9.81	2003.475	-249.9	164.3	-246.4	164.1	LDS 4470
217.4493	42.2564	15.37	17.50	120.11	41.82	2003.177	-88.0	-7.8	-87.6	-6.9	SLW 1002
217.7336	13.0201	17.30	18.40	294.19	11.80	2003.472	33.9	-80.1	37.5	-75.3	CBL 456
217.9205	6.4495	14.62	16.56	30.70	103.98	2001.457	-86.8	-13.7	-87.9	-17.2	NEW
218.1465	-1.3872	16.84	17.18	73.44	35.79	2001.394	-68.5	17.5	-67.4	16.6	NEW
218.9413	4.9698	16.82	16.96	335.38	51.82	2001.214	32.5	-163.0	33.8	-167.7	CBL 461
218.9590	0.7096	15.63	17.36	138.09	49.80	1999.221	79.8	-88.4	81.2	-88.7	CBL 462
219.8853	51.9061	15.26	16.42	102.70	13.04	2003.188	-87.0	81.9	-88.0	85.7	LDS 4487
220.5172	16.8932	16.10	16.89	266.12	32.22	2005.354	-72.5	10.5	-68.9	12.4	CBL 465
220.5792	26.2453	15.95	17.41	316.52	13.86	2004.365	49.0	-124.6	51.0	-125.3	LDS 4490
220.6966	28.1224	14.51	15.37	184.73	95.82	2004.308	56.0	-85.4	56.5	-87.3	CBL 466

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
221.4351	26.6369	17.89	19.92	307.41	68.98	2004.308	12.1	-85.3	14.1	-84.3	NEW
221.9265	34.6576	13.77	16.75	6.57	97.99	2003.475	-69.5	35.4	-70.6	37.8	NEW
222.0107	46.9666	16.75	18.02	290.88	8.60	2003.324	42.6	-88.9	45.2	-85.2	SLW 1033
223.2703	53.9476	15.97	17.77	182.49	73.94	2002.437	-26.5	78.0	-24.5	78.7	CBL 473
223.4139	7.3574	15.17	15.82	180.28	23.95	2003.319	-62.6	-27.5	-66.5	-30.4	NEW
225.1837	40.1749	17.57	18.43	73.55	10.87	2003.191	-0.9	-91.1	-1.9	-91.0	SLW 1051
225.1978	23.1075	15.45	16.42	338.92	26.22	2004.392	-171.7	113.9	-171.6	114.7	LDS 4521
225.5044	60.9530	15.53	15.55	341.01	26.83	2001.225	44.5	-91.9	47.9	-94.8	SLW 1053
225.8068	39.4541	16.35	18.34	115.91	9.22	2003.191	-79.3	-69.4	-75.3	-70.4	SLW 1055
226.1840	22.5274	16.50	19.65	280.39	20.33	2004.447	47.5	-66.4	46.5	-68.3	SLW 1057
227.0363	61.4387	16.96	18.49	308.23	12.12	2001.225	5.6	-67.7	2.0	-64.0	NEW
227.5123	22.0986	18.38	19.25	84.78	24.73	2004.447	22.9	-66.2	23.8	-67.1	NEW
228.1499	30.9517	13.91	16.15	240.08	41.51	2003.475	19.5	-63.7	22.1	-65.1	CRB 109
228.3403	8.6389	14.41	17.05	152.85	24.78	2003.245	-123.6	-20.4	-124.8	-24.4	CBL 481
228.8172	0.4073	17.21	17.88	331.35	20.78	1999.221	-83.0	-23.3	-79.9	-27.2	NEW
228.9839	22.4085	20.35	21.29	242.15	77.64	2004.390	19.8	-72.6	19.2	-75.0	NEW
229.3205	47.5232	16.44	16.64	158.54	18.93	2002.353	-53.8	116.9	-54.4	117.4	GRV 1207
229.3452	35.9369	15.48	17.10	26.71	10.37	2003.226	-94.6	-75.4	-92.2	-78.6	LDS 5165
229.7218	19.0649	15.50	16.86	174.31	11.71	2004.452	0.1	-68.6	0.0	-68.0	UC 2982
230.1532	55.1371	13.48	17.17	101.37	17.10	2005.428	-77.3	82.5	-76.2	83.5	CBL 486
230.3062	27.7479	17.66	17.91	184.40	59.58	2004.209	-140.0	-121.4	-137.6	-120.7	LDS 4544
230.3599	53.2034	14.95	15.06	137.01	10.95	2001.375	-64.6	87.0	-63.2	88.6	GRV 1209
230.8539	11.1754	14.37	14.48	54.22	23.50	2005.364	-22.0	-74.3	-24.0	-73.1	NEW
231.2795	57.5020	16.00	18.35	348.53	32.89	2006.331	45.1	-63.7	43.2	-63.9	CRB 195
231.2888	27.5664	16.46	18.79	130.23	7.80	2003.480	28.2	-78.4	29.5	-79.6	AZC 90
231.4670	12.5347	15.20	17.29	31.91	46.66	2005.362	2.8	-75.5	4.9	-76.9	CBL 488
231.5453	-2.8570	15.49	15.60	222.58	21.35	2001.454	-20.3	-111.6	-22.8	-108.1	UC 3003
231.7055	27.3091	16.27	16.94	257.28	13.68	2003.480	38.4	-69.7	42.7	-72.9	AZC 91
231.9668	49.1484	16.00	17.01	344.89	55.10	2002.437	-60.8	50.2	-63.6	53.2	SLW 1095
232.0655	29.3386	17.38	17.95	57.36	13.01	2003.317	-72.8	-14.5	-69.1	-13.8	NEW
232.9907	13.3573	13.83	16.27	186.99	13.70	2005.359	-128.4	-36.2	-128.3	-33.6	LDS 4557
233.0902	56.9993	18.33	18.73	251.95	8.62	2000.321	-64.3	-67.7	-65.8	-67.6	SLW 1103
233.5381	40.7901	14.01	17.64	293.80	11.34	2003.324	88.7	-131.3	87.8	-132.0	LDS 4562
233.5712	63.8920	16.08	18.12	110.16	8.17	2005.416	-1.8	-65.5	2.2	-66.8	NEW
234.4683	0.2850	16.60	16.70	283.41	52.00	1999.221	33.9	-466.8	34.9	-466.6	LDS 4575
234.9551	2.4947	14.42	16.97	132.49	101.55	2001.392	-115.4	-10.6	-115.7	-8.6	NEW
235.8304	40.4027	15.51	17.44	315.76	36.80	2003.324	16.1	-137.0	16.6	-137.6	CBL 494
236.3961	42.0852	13.98	14.29	253.62	60.77	2002.350	87.1	-10.4	89.5	-11.2	UC 212
236.3975	18.9915	17.03	17.87	288.29	11.57	2004.393	-76.1	-7.3	-79.7	-9.6	SLW 1135
236.4010	56.9842	16.46	17.45	31.07	8.62	2000.321	12.9	-65.6	8.5	-63.8	NEW
236.8494	53.4087	15.72	18.85	191.89	11.12	2000.261	-13.2	63.0	-11.1	63.2	NEW
237.0738	4.7261	16.62	17.22	59.51	10.92	2001.457	-3.9	-64.8	-0.6	-64.6	SLW 1138
237.3033	45.0279	15.43	18.79	310.79	10.39	2002.353	-9.1	-72.1	-7.2	-71.8	NEW
237.5326	18.3661	16.03	18.19	139.48	54.53	2004.447	-24.2	-66.1	-21.2	-63.7	NEW
237.8183	6.3459	18.82	19.46	141.01	13.35	2003.319	-29.1	-63.6	-29.4	-65.9	NEW
237.9101	61.1431	16.84	17.24	282.11	15.17	2004.455	-7.8	-60.2	-11.0	-60.3	NEW
238.2828	22.8490	14.64	18.00	247.29	38.71	2004.291	-211.9	-162.3	-215.9	-162.9	LDS 4598
238.5167	44.4289	15.70	15.93	188.90	14.02	2002.437	-93.1	106.7	-93.8	106.9	LDS 1428
238.7548	35.2288	17.55	17.78	162.63	75.61	2003.404	-67.9	16.8	-70.8	17.7	NEW
238.8730	15.7088	16.44	17.62	188.70	55.96	2004.452	-83.6	61.0	-80.8	64.5	LDS 4602

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
238.8828	49.0735	17.15	18.14	3.51	21.50	2001.375	-2.1	-96.3	0.5	-97.9	NEW
238.9321	26.0516	14.34	16.01	63.69	30.06	2003.475	-220.5	84.5	-221.3	82.6	LDS 4604
239.3731	3.4011	17.68	19.30	292.29	21.32	2003.322	15.7	-65.7	16.4	-69.2	NEW
239.7728	51.7971	14.64	14.86	269.95	79.23	2001.290	-9.0	78.5	-6.9	74.3	NEW
241.3093	-17.6722	16.16	16.27	302.77	25.92	2007.300	38.5	-100.8	40.9	-101.5	LDS 4630
241.3806	29.9235	15.90	17.59	140.86	8.31	2003.472	-22.2	78.7	-25.8	79.3	GRV 1217
241.7064	14.7358	14.48	17.85	316.10	66.19	2004.453	-22.6	67.0	-25.6	67.0	NEW
242.4293	52.1786	14.59	17.00	236.76	11.47	2000.321	-69.6	-5.1	-66.4	-3.0	NEW
242.8577	43.0924	17.11	17.50	145.73	15.77	2002.437	30.1	-64.0	25.3	-67.6	NEW
242.9587	34.6981	20.44	20.98	85.63	44.44	2003.407	-47.7	79.2	-46.1	81.3	NEW
243.5141	53.8250	13.28	17.08	322.32	26.50	2003.481	53.8	-97.9	57.2	-102.8	LDS 4655
244.1729	22.7805	14.62	18.96	103.13	9.36	2003.317	36.5	-67.6	40.8	-69.4	AZC 97
244.2595	-0.1013	15.70	20.40	352.29	18.76	1999.216	-19.7	-81.6	-14.9	-84.1	NEW
244.8640	56.3326	15.69	16.09	58.01	78.25	2005.416	-61.5	-18.2	-63.4	-21.0	NEW
245.4876	35.3981	17.29	17.79	356.63	25.89	2002.350	-9.0	-64.9	-4.6	-68.1	NEW
245.8345	38.7316	15.63	17.11	301.56	75.11	2002.437	-135.8	138.9	-138.7	138.5	LDS 4664
246.2437	-5.1642	16.30	17.81	195.73	44.93	2005.425	-26.8	-113.1	-25.0	-111.0	NEW
246.8698	7.6775	17.37	19.51	323.65	25.58	2005.365	-14.5	-62.0	-10.5	-66.1	NEW
248.0291	7.3279	18.84	20.09	265.98	89.32	2003.472	-19.3	-61.6	-20.4	-60.7	NEW
248.3748	46.0599	15.53	15.99	39.52	19.24	2001.225	-38.3	66.7	-40.6	66.4	BVD 247
249.1048	37.7952	14.25	17.65	261.25	21.21	2002.438	-105.7	3.3	-106.6	0.0	LDS 4680
249.2637	12.2270	15.22	15.67	254.86	33.01	2004.453	-37.4	-61.5	-36.7	-60.0	BPM 665
249.3832	53.8559	15.27	15.37	83.29	15.10	2005.416	13.4	-74.8	12.8	-76.0	SLW 1188
249.5384	48.6414	17.65	18.37	314.95	34.56	2004.453	-46.3	70.5	-45.2	66.6	SLW 1189
249.5767	50.6736	14.54	17.46	269.98	15.39	2003.481	-25.3	-65.3	-29.4	-65.1	NEW
251.0388	37.8350	17.65	19.24	147.75	87.93	2001.378	9.8	-69.3	11.2	-70.2	NEW
252.4825	79.5342	16.93	17.46	138.24	24.37	2003.483	-37.0	67.1	-41.4	66.9	NEW
252.8689	18.2349	20.19	20.38	300.12	110.41	2003.317	1.1	-61.8	-2.6	-60.4	NEW
253.6643	50.8689	16.98	17.43	63.95	18.21	2005.417	-46.3	97.9	-46.3	98.0	GRV 1223
255.1078	28.2857	15.97	17.52	120.80	18.58	2004.709	-133.4	4.9	-134.9	3.0	LDS 4717
255.1082	23.7566	15.03	16.88	259.02	17.97	2003.325	-26.5	-64.2	-27.1	-67.5	NEW
255.1260	33.2270	15.63	16.45	289.30	27.12	2001.392	-44.8	-66.8	-46.1	-67.0	CBL 513
255.6099	11.7654	14.78	19.43	195.98	8.66	2005.438	2.6	-89.0	5.5	-89.4	NEW
256.1921	73.0997	15.40	17.23	65.13	78.56	2001.720	60.6	-31.9	64.2	-35.5	NEW
256.2522	28.1493	16.55	16.77	90.28	27.71	2003.180	2.6	66.4	4.2	69.0	NEW
256.2693	59.4490	16.74	19.80	102.63	12.41	2000.259	0.9	-129.7	1.2	-127.7	NEW
257.6061	27.9777	11.98	16.83	128.88	48.11	2002.438	19.5	-86.6	23.1	-87.9	SKF 366
257.9359	-0.5620	12.97	16.07	272.62	15.28	2001.411	115.2	-78.7	115.1	-77.0	LDS 4724
258.7007	43.1964	15.75	16.13	60.63	14.79	2004.455	24.9	-125.9	26.5	-125.7	LDS 4731
259.0877	-2.1036	17.92	20.70	148.82	102.39	2005.433	13.2	-67.1	17.4	-64.5	NEW
259.3079	36.0540	18.44	18.54	202.79	61.16	2003.481	-34.5	-139.7	-37.0	-142.3	NEW
259.5219	27.0971	18.44	20.77	37.96	111.86	2001.378	-21.9	-74.1	-19.6	-74.7	NEW
260.6460	29.5177	13.98	18.52	342.23	31.55	2000.261	-20.7	-171.3	-25.1	-175.9	FMR 132
261.8348	33.9072	13.30	20.99	353.26	52.86	2004.456	-2.8	80.2	-1.8	76.2	NEW
263.6019	4.9193	18.61	20.17	117.45	5.76	2005.433	-10.8	-106.5	-14.3	-102.6	NEW
263.8870	6.0532	14.60	17.63	236.63	27.04	2005.425	19.7	-107.2	20.8	-107.8	NEW
264.1361	7.1297	14.47	15.78	34.50	51.48	2003.639	31.7	-102.4	35.8	-103.7	UC 3374
264.4001	67.7244	17.35	17.59	193.14	31.99	2001.720	49.5	106.3	52.7	104.7	AZC 177
264.7749	65.1519	15.96	17.80	109.10	17.47	2001.720	-3.7	113.5	0.1	111.5	NEW
264.9433	5.6246	16.63	16.97	249.21	9.34	2005.425	-128.4	-153.1	-129.0	-153.2	FMR 137

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
265.0576	28.4391	19.04	19.45	215.88	14.53	2004.453	-43.0	-67.7	-46.2	-72.0	NEW
266.7337	64.9359	14.93	15.08	144.47	23.13	2006.331	-81.5	105.3	-84.3	103.2	LDS 2741
266.8601	44.1455	16.13	17.81	302.75	10.69	2005.444	0.3	-79.7	3.2	-80.9	NEW
267.1462	46.0976	15.63	18.12	34.33	19.82	2001.717	-1.2	80.8	2.2	77.3	CBL 518
267.1944	5.6933	17.40	17.50	219.32	14.05	2003.639	20.5	-60.9	21.1	-63.6	NEW
267.4790	41.8551	17.03	17.80	177.96	10.68	2002.760	-31.7	89.4	-31.8	89.2	LDS 4765
269.2249	78.4767	14.23	14.52	276.43	53.85	2003.740	11.2	-66.3	12.9	-66.8	NEW
269.3062	0.9325	14.72	20.79	303.91	69.44	2000.344	14.1	-64.6	17.8	-66.0	NEW
269.6317	0.7237	18.81	20.37	213.99	108.40	2002.337	-5.3	60.4	-7.8	60.2	NEW
270.2203	0.8416	13.57	16.56	355.95	25.90	2000.344	-35.2	-76.8	-39.1	-72.8	NEW
272.8278	0.9743	19.65	19.97	345.72	99.83	2000.344	-27.5	-63.6	-26.4	-65.2	NEW
274.2337	64.2448	16.72	17.71	44.36	12.65	2006.394	-42.0	-246.4	-42.8	-248.1	SLW 1218
280.6273	-0.2593	17.84	20.10	89.26	75.79	2003.639	-12.4	-75.0	-11.9	-77.9	NEW
281.5963	39.9721	14.55	16.36	70.73	10.56	2005.435	-129.4	19.2	-124.6	18.3	LDS 4799
291.1071	14.7860	20.00	20.90	226.25	83.38	2004.707	-1.0	-65.3	3.0	-66.8	NEW
291.5741	15.4872	17.21	17.71	253.40	80.12	2004.707	4.7	68.3	0.8	67.9	NEW
294.3393	63.3232	19.12	19.67	307.11	19.43	2006.394	12.9	73.2	12.7	72.3	NEW
295.2510	23.2820	20.08	20.20	43.21	19.22	2007.625	14.3	77.7	11.2	74.4	NEW
296.7048	62.6387	16.94	18.26	83.27	8.17	2006.397	12.2	69.5	15.8	69.8	BVD 334
298.4580	10.3515	18.31	19.84	283.52	110.82	2004.707	-7.4	-62.0	-6.7	-65.2	NEW
299.6021	60.5317	13.12	18.34	246.16	51.58	2006.397	2.1	96.1	1.1	96.2	CBL 524
302.1205	60.3984	15.64	16.06	355.45	74.14	2006.397	-79.5	-30.3	-82.1	-27.3	CBL 525
302.3434	33.1282	14.86	15.56	359.56	35.01	2006.402	114.9	-203.1	111.2	-199.2	GIC 162
302.4844	41.9991	18.32	19.69	210.16	113.06	2003.735	16.2	-60.1	15.3	-62.4	NEW
303.4920	7.2232	19.17	20.13	238.07	102.10	2004.710	-6.6	-72.2	-1.9	-70.8	NEW
303.7531	32.7298	20.52	21.53	55.86	35.92	2006.402	5.3	-65.6	3.0	-64.3	NEW
304.1702	8.0382	19.78	20.76	284.68	97.60	2004.707	0.4	65.9	4.6	70.7	NEW
304.6610	-11.4369	15.22	18.06	38.56	27.87	2005.444	-55.2	-121.8	-52.8	-121.3	NEW
306.7294	0.7565	16.35	17.25	216.91	35.56	2001.788	0.9	-64.6	-2.5	-66.4	NEW
307.4056	-5.5173	15.43	17.93	84.90	35.98	2000.674	-63.4	-86.3	-58.6	-87.1	NEW
308.7576	-13.3905	15.26	16.90	36.10	18.43	2005.452	69.8	32.8	72.3	30.6	NEW
309.0652	-13.3370	16.12	17.69	221.12	9.78	2005.444	-52.4	-90.3	-55.5	-92.5	NEW
309.7707	27.1608	19.95	20.22	319.80	43.28	2006.402	-9.1	68.2	-12.6	70.9	NEW
310.0914	-6.1701	14.93	16.99	73.39	35.09	2000.740	6.6	-67.2	11.1	-66.8	NEW
311.5927	45.8478	14.49	19.49	7.16	111.96	2000.937	-48.7	-63.2	-50.2	-63.1	NEW
312.0350	39.9707	14.82	16.75	358.83	9.66	2003.735	66.4	16.8	66.4	12.3	NEW
312.0630	75.3106	16.15	17.13	132.87	10.03	2003.738	89.8	185.9	91.6	189.5	LDS 1940
312.4928	57.8417	19.50	19.94	318.98	112.14	2006.410	-7.6	-68.1	-9.8	-69.5	NEW
313.6640	42.1775	20.05	20.78	234.76	61.41	2003.719	-0.9	-89.2	-1.7	-91.3	NEW
314.0111	-5.9222	15.60	16.04	183.62	73.70	2000.674	-11.8	-89.4	-10.9	-88.8	UC 4333
314.3734	-11.7008	13.02	17.52	320.65	48.68	2004.699	76.9	51.4	80.1	52.3	NEW
315.2225	-3.2735	17.11	18.20	297.29	75.40	2008.887	-47.7	-74.0	-44.2	-73.8	NEW
315.5343	3.4863	18.28	18.64	278.88	69.70	2008.816	-1.5	-79.1	-1.8	-80.2	NEW
315.8179	-17.6377	20.13	20.52	307.07	73.60	2005.452	1.2	-61.4	-1.5	-62.7	NEW
316.2584	-3.1529	16.79	18.42	78.62	23.46	2009.774	28.3	64.3	28.3	66.6	NEW
317.2117	54.9814	19.53	19.65	189.94	93.88	2006.410	-11.5	60.4	-9.7	62.1	NEW
318.2369	-0.7460	16.32	16.39	210.79	14.00	2003.795	67.5	3.5	68.5	6.5	SLW 1231
318.4494	74.1492	14.99	16.45	167.89	32.70	2003.738	30.7	71.1	30.8	72.0	CBL 91
319.6920	21.8327	17.20	17.86	9.77	12.56	2008.732	-62.2	71.8	-65.2	70.4	LDS 4878
320.2728	53.6226	17.31	19.30	21.12	64.35	2006.394	3.0	-70.0	6.9	-73.8	NEW

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
320.5836	51.5355	16.72	19.27	156.06	74.95	2006.394	24.4	-66.7	24.1	-64.7	NEW
321.0934	-10.5503	19.72	19.82	34.86	114.43	2008.732	-16.3	-63.0	-18.9	-62.2	NEW
321.3466	52.5830	19.28	19.63	319.38	113.02	2006.410	23.3	63.7	27.8	65.9	NEW
321.4797	52.2311	20.43	20.85	111.88	54.45	2006.394	-27.6	68.1	-23.5	67.8	NEW
321.5872	7.1116	13.53	17.76	103.53	91.92	2008.827	-9.0	-73.6	-6.9	-70.6	NEW
321.7870	51.8578	17.34	19.63	51.32	71.96	2006.394	-3.7	78.1	-4.6	76.6	NEW
322.0926	19.3974	20.38	20.64	262.83	79.74	2004.712	13.4	-65.4	9.7	-67.3	NEW
323.2605	17.3657	19.12	19.48	80.42	114.90	2006.402	33.3	64.4	29.5	63.9	NEW
323.2859	-2.2200	14.23	18.92	315.08	94.97	2008.882	56.4	-66.7	60.0	-66.1	NEW
323.5443	50.4402	17.23	18.17	114.09	119.73	2006.410	6.4	-62.7	6.0	-65.1	NEW
324.9261	14.3850	16.22	17.71	319.32	18.41	2007.448	-18.1	-108.6	-18.3	-108.1	LDS 4901
325.2194	25.5337	14.50	16.43	199.32	9.51	2009.876	-88.8	-45.5	-87.8	-50.3	AZC 113
325.3350	23.9111	14.03	20.07	163.68	11.36	2009.859	29.9	-113.9	30.9	-114.0	NEW
325.4102	20.9826	13.99	14.00	33.44	69.77	2004.783	74.0	-10.5	76.3	-9.6	UC 4531
325.7705	24.2164	16.63	19.79	38.90	9.67	2009.797	116.4	-71.1	120.8	-67.9	NEW
325.7925	13.8314	17.04	17.87	305.13	13.51	2009.739	-43.3	-66.8	-47.9	-64.2	CBL 534
326.2730	0.3672	17.65	18.75	143.20	18.94	2003.811	-71.1	-63.2	-71.5	-62.9	SLW 1252
328.0672	23.7417	17.91	19.01	98.25	40.16	2009.794	-9.3	-70.0	-7.5	-70.0	NEW
328.6062	7.6378	17.12	17.93	72.81	13.06	2008.827	-78.4	-94.1	-73.7	-92.0	NEW
329.1905	-4.4500	14.18	17.18	309.64	71.95	2009.775	65.3	-15.3	61.4	-19.1	NEW
329.4003	-3.4697	15.01	18.36	128.20	37.04	2009.775	166.5	-129.6	162.2	-133.6	LDS 4926
330.3202	-2.3535	14.79	15.60	299.26	12.66	2009.709	49.1	-92.1	49.2	-90.9	NEW
331.2027	22.4412	16.78	17.08	40.98	35.47	2004.784	-106.9	-56.0	-109.4	-54.7	CBL 538
331.2363	-9.6061	16.30	17.26	347.57	15.21	2004.710	-34.2	-106.1	-34.9	-102.0	NEW
331.3875	25.3995	15.20	15.74	243.09	75.47	2009.797	-7.7	-173.9	-12.3	-172.1	FMR 168
331.6505	6.8764	16.21	19.02	345.22	71.32	2005.742	-19.6	-65.2	-16.5	-64.8	SLW 1261
331.8189	8.7040	17.07	19.81	126.93	32.85	2004.699	46.8	-85.3	48.7	-85.3	NEW
332.1345	2.1601	15.36	16.77	187.91	32.29	2008.756	119.8	-170.1	118.9	-170.8	LDS 4945
333.3313	25.0324	15.39	17.48	204.99	29.73	2009.797	-18.2	-60.0	-16.5	-60.2	NEW
333.9568	0.9589	17.63	18.29	303.98	7.36	2008.756	-11.2	-144.6	-9.1	-144.4	LDS 4952
334.1306	18.7533	14.41	17.40	16.86	105.27	2009.794	73.8	15.2	76.4	13.7	NEW
335.8782	31.9892	14.57	16.10	168.49	34.06	2009.878	144.4	69.8	140.7	69.1	LDS 4964
336.0963	-1.6424	13.26	13.45	296.58	83.45	2009.709	227.4	-377.1	223.7	-382.1	GIC 180
336.8214	18.0835	13.22	16.27	243.16	33.63	2009.789	70.8	-23.0	67.1	-22.5	NEW
336.9505	-4.0455	18.14	18.59	328.92	18.94	2009.737	27.5	-116.1	29.3	-113.0	NEW
337.4019	-7.2731	15.65	18.34	70.30	34.35	2009.791	22.5	-92.9	22.6	-89.3	NEW
337.7115	21.0546	18.26	18.32	8.13	29.22	2009.791	-35.9	-78.2	-39.3	-76.9	NEW
337.9365	13.3233	16.42	18.17	298.25	10.54	2000.740	-12.9	-74.7	-13.5	-75.2	CBL 541
338.3175	-7.9104	17.62	18.35	163.43	13.02	2009.788	-64.8	80.2	-63.4	79.7	SLW 1278
338.9853	24.4336	16.96	17.04	137.60	13.77	2009.794	75.3	12.1	75.1	16.4	NEW
339.0294	4.0376	16.09	16.19	120.21	57.12	2008.816	-48.4	-75.2	-51.1	-73.0	NEW
339.3326	22.4123	13.87	14.98	348.47	15.36	2004.712	95.1	0.9	92.1	5.7	UC 276
339.7480	11.5732	16.82	17.28	20.32	90.41	2008.828	4.2	-68.2	0.7	-69.8	NEW
339.8554	3.6573	15.37	17.04	281.56	35.31	2008.816	82.8	-6.2	81.8	-5.2	NEW
340.0931	10.7247	16.86	17.69	15.45	22.80	2008.839	46.1	-131.9	48.1	-134.5	NEW
340.1422	4.8130	15.05	15.93	187.26	12.45	2008.816	116.0	-46.6	115.0	-47.6	UC 4788
342.3576	5.2832	14.86	17.38	303.19	26.47	2008.816	106.0	50.4	104.1	49.9	LDS 5002
342.8887	13.5764	15.78	17.17	318.56	55.44	2001.715	-51.0	-61.4	-47.1	-60.9	NEW
343.2650	27.4462	16.75	17.40	52.55	12.90	2009.797	179.9	-8.6	180.8	-7.6	LDS 5012
343.3717	23.5880	15.04	17.11	190.76	16.74	2008.751	82.8	-1.8	83.5	-1.4	LDS 5014

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS NAME
							PM RA	PM DE	PM RA	PM DE	
344.2093	18.8216	14.93	15.27	166.95	110.75	2009.057	66.8	-27.0	65.0	-25.8	NEW
344.2563	19.7471	15.23	18.13	307.09	54.44	2009.057	181.4	119.5	184.5	116.2	LDS 5024
344.7357	20.2218	15.37	16.25	235.62	21.19	2009.791	-49.7	-117.9	-48.8	-117.4	LDS 5033
345.0863	58.6101	19.44	20.23	227.58	37.48	2003.738	36.5	-62.5	37.1	-61.0	NEW
345.1376	10.2863	19.13	19.18	129.04	22.67	2008.836	8.8	-68.0	5.6	-64.7	NEW
346.1311	-19.3387	16.23	16.66	146.64	29.21	2004.953	117.5	-19.2	117.7	-21.8	UC 4874
347.1577	1.4628	14.61	14.65	202.03	37.13	2008.753	118.9	-51.9	117.4	-50.6	LDS 6008
347.7866	57.8106	19.55	20.21	331.89	88.75	2003.738	-36.1	72.4	-33.2	71.3	NEW
347.9436	58.2237	17.90	18.90	174.75	80.17	2003.738	2.3	69.5	-2.2	65.1	NEW
348.8313	-6.8810	14.17	16.74	327.36	81.18	2009.791	10.3	-78.7	12.2	-78.8	NEW
349.3903	57.4171	17.58	19.50	197.42	90.75	2003.738	-5.4	62.7	-3.6	64.8	NEW
349.5095	5.3496	14.57	16.55	216.02	51.74	2008.879	123.8	75.8	121.3	72.4	NEW
349.5244	-7.3409	16.97	17.88	150.80	17.77	2009.791	10.5	-136.2	12.6	-134.8	LDS 2978
349.8584	15.6379	16.26	18.09	82.07	13.21	2006.708	-26.9	-79.8	-26.6	-78.6	CBL 547
349.9249	53.1805	15.84	17.96	272.65	30.89	2003.738	19.5	62.1	16.9	65.8	NEW
349.9718	-1.0904	15.61	18.12	323.93	23.39	2003.741	-48.1	-76.4	-48.3	-73.2	CBL 548
350.4113	29.7427	15.85	17.53	233.24	16.55	2009.797	116.8	15.4	116.7	18.0	LDS 5077
350.7054	23.3744	15.86	15.95	176.62	12.68	2008.732	138.9	-24.3	142.8	-25.4	AZC 129
350.9869	-7.8473	14.84	17.40	137.32	11.90	2009.791	53.4	69.4	56.8	65.9	LDS 2986
351.0937	35.0785	16.31	20.45	349.31	21.73	2009.879	-42.8	-79.5	-38.9	-81.2	NEW
351.3788	3.4928	16.20	17.48	187.37	53.84	2008.753	62.1	-106.1	62.6	-107.1	NEW
352.1281	-3.6990	15.29	16.68	65.25	22.26	2008.888	64.4	-10.0	64.0	-9.8	NEW
352.4656	31.6811	17.76	18.34	223.27	94.47	2009.876	-8.0	-77.2	-9.8	-74.1	NEW
352.7752	8.7004	13.59	14.96	359.00	30.77	2008.836	223.5	89.8	226.6	89.1	GIC 194
353.0244	15.2238	15.57	16.63	340.25	89.68	2001.644	73.2	-5.9	72.1	-1.5	NEW
353.2963	22.1927	14.35	16.67	212.50	63.85	2009.794	-64.2	-31.9	-61.5	-32.3	UC 4981
353.3449	3.7616	15.06	17.89	126.90	43.66	2008.879	93.6	12.2	98.4	12.3	NEW
353.4344	33.2785	15.23	15.30	242.61	14.43	2009.879	-85.7	-55.3	-84.9	-55.3	LDS 5102
354.1972	25.4950	17.19	18.71	311.78	12.63	2004.713	-39.4	69.3	-43.9	68.4	NEW
354.2788	-1.4730	14.01	17.10	37.95	66.72	2009.709	62.0	3.8	60.6	-0.8	NEW
354.3734	6.3137	15.86	16.21	73.33	16.39	2005.698	112.5	-37.3	112.0	-37.6	SLW 1329
354.5753	61.7184	14.60	14.63	173.40	29.77	1999.765	90.2	-0.5	88.0	0.0	NEW
354.6033	69.1896	20.50	22.00	171.26	69.68	1999.765	19.5	64.3	20.8	65.0	NEW
354.7499	3.7143	18.00	18.31	162.55	115.37	2008.754	-29.2	-61.2	-25.7	-61.4	NEW
354.9839	-1.4498	16.74	18.58	164.60	15.29	2009.709	-105.5	-185.5	-108.6	-190.3	LDS 5110
355.3478	-5.4040	18.75	18.97	158.33	78.99	2008.888	-4.5	-61.2	-0.6	-61.6	NEW
355.4222	1.0870	15.37	18.67	24.75	7.87	2001.789	-38.4	-71.0	-33.8	-73.9	NEW
356.1779	-5.1651	17.78	17.96	321.68	24.08	2009.742	-73.0	-40.1	-70.2	-38.5	LDS 6056
356.2283	28.2342	13.90	15.24	240.42	31.61	2009.792	119.5	-53.0	115.2	-51.7	LDS 5117
356.2721	21.1019	17.03	18.09	209.57	22.73	2009.794	-63.6	-122.6	-63.1	-121.5	LDS 5118
356.4222	-19.6774	15.84	17.89	102.13	111.89	2004.953	60.6	5.0	65.2	6.3	NEW
356.4882	12.3709	13.68	16.02	129.32	42.85	2008.839	128.7	-9.4	130.0	-11.4	NEW
357.4130	10.4626	16.14	16.79	314.64	17.19	2008.836	120.0	-67.8	116.8	-69.8	NEW
358.2733	7.4509	18.44	19.34	338.64	16.38	2005.698	-57.5	-156.4	-56.5	-157.4	NEW
358.2780	-8.4969	14.83	17.91	32.66	35.27	2009.791	-191.2	-226.6	-192.9	-228.7	LDS 3003
358.4323	8.4169	15.05	15.93	276.92	60.96	2005.698	-68.9	-5.3	-64.1	-6.9	NEW
358.6469	24.4626	15.01	16.07	124.11	14.41	2008.751	88.4	-29.5	89.1	-28.2	CBL 550
358.8996	15.0600	20.66	21.00	244.90	81.48	2001.644	9.3	-62.3	8.7	-63.3	NEW
359.1769	8.4959	18.25	19.64	329.95	70.81	2005.698	-53.0	-65.8	-51.3	-65.0	NEW
359.3094	29.9884	17.21	18.38	203.86	11.98	2003.738	40.6	-70.6	39.8	-67.7	AZC 132

### Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars

PRIMARY RA	PRIMARY DEC	MAG A	MAG B	PA	SEP	DATE	PRIMARY		SECONDARY		WDS	NAME
							PM RA	PM DE	PM RA	PM DE		
359.5415	30.9672	15.42	15.95	62.67	34.84	2003.738	140.3	-7.1	141.2	-7.8	LDS	5144
359.7226	1.8124	13.59	14.21	143.26	37.83	2008.756	69.0	-19.6	67.0	-20.3	UC	300
359.8908	-10.6220	14.94	17.74	3.74	15.06	2000.680	121.3	-71.0	118.7	-67.7	LDS	5150

PRIMARY RA	PRIMARY DEC	NAME	PRIMARY		SECONDARY		TYPE M+	TYPE M+
			(r-i)	(i-z)	(r-i)	(i-z)		
1.4044	-1.6654	LDS 3012	1.38	0.75	1.56	0.86	4	5
1.6852	-0.9035	GWP 13	0.95	0.51	1.22	0.63	2	3
1.8549	-5.3131	GWP 15	0.72	0.32	1.22	0.63	0	3
2.1427	18.8297	LDS 3126	1.40	0.73	1.36	0.63	4	4
2.4115	1.8063	GWP 22	0.84	0.52	1.36	0.79	2	4
2.4421	23.9435	LDS 3131	1.60	0.88	1.79	1.12	5	6
2.6793	34.2905	NEW	0.86	0.50	1.30	0.74	2	4
3.6267	21.3149	LDS 3141	0.74	0.39	1.19	0.61	1	3
3.8319	17.8980	LDS 3145	1.77	0.90	2.05	1.05	5	6
4.2745	-12.0791	CBL 202	1.07	0.50	1.16	0.59	2	3
4.5137	-6.5172	GWP 37	0.71	0.41	0.95	0.54	1	2
4.9296	19.8531	GWP 40	0.53	1.95	1.61	0.88	5	5
5.2741	-10.0117	LDS 5268	0.92	0.48	1.33	0.67	2	4
5.4128	21.7372	NEW	1.14	0.59	1.16	0.61	3	3
5.4547	8.8241	NEW	0.97	0.54	1.81	1.00	2	6
6.0506	15.0750	GWP 44	1.07	0.59	1.41	0.75	3	4
6.1267	36.5557	CRB 27	1.63	0.82	2.19	1.14	5	7
6.2231	13.9184	GWP 45	1.22	0.58	1.33	0.68	3	4
6.3559	26.0631	LDS 3166	1.82	0.55	2.02	1.02	4	6
6.4710	-9.1188	GWP 48	0.62	0.37	1.05	0.59	0	3
6.7456	-1.4262	GWP 50	0.79	0.43	1.55	0.78	1	5
6.7699	-6.4551	LDS 3169	1.77	0.98	2.26	1.19	6	7
7.2477	-9.5794	GIC 10	0.83	0.43	1.02	0.53	1	2
7.9124	12.1549	NEW	0.68	0.38	1.34	0.73	1	4
8.1133	14.4490	GRV 975	1.02	0.56	1.13	0.59	2	3
8.5745	26.9980	NEW	1.28	0.68	1.50	0.80	4	5
8.9132	19.4773	NEW	1.41	0.82	1.36	0.79	4	4
8.9144	19.4055	NEW	1.35	0.71	1.44	0.77	4	4
9.7764	27.0619	AZC 5	1.22	0.62	1.26	0.64	3	3
9.7967	34.4952	CRB 31	1.35	0.70	1.50	0.82	4	5
9.9562	28.2812	LDS 3187	1.45	0.76	1.52	0.79	4	5
10.0125	-20.9960	SLW 35	1.46	0.76	1.65	0.87	4	5
10.6490	32.2209	CRB 32	0.93	0.50	1.39	0.73	2	4
10.7680	29.6904	NEW	0.52	0.33	1.34	0.75	0	4
10.7878	-22.1988	NEW	1.10	0.65	1.00	0.58	3	2
10.7979	-4.0289	NEW	0.59	0.36	1.08	0.63	0	3
12.1660	12.4297	NEW	1.11	0.60	0.98	0.52	3	2
12.7719	22.5095	AZC 7	0.99	0.51	1.27	0.63	2	3
12.9979	34.5433	UC 450	0.85	0.41	1.24	0.58	1	3
13.4329	-3.6179	NEW	1.06	0.56	0.65	1.04	2	3
13.7828	31.0324	CRB 36	0.62	0.36	0.75	0.42	0	1
14.1045	5.8013	GWP 105	0.72	0.34	0.85	0.40	1	1
14.3928	2.2630	NEW	1.48	0.77	1.33	0.68	4	4
14.4232	4.6839	GWP 107	1.17	0.65	1.38	0.70	3	4
14.4819	-3.4199	NEW	1.18	0.56	1.25	0.64	3	3

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	NAME	PRIMARY		SECONDARY		TYPE M+	TYPE M+
			(r-i)	(i-z)	(r-i)	(i-z)		
14.7040	10.7366	GWP 109	0.69	0.40	1.16	0.66	1	3
15.0241	12.7700	GWP 113	1.13	0.62	1.45	0.74	3	4
15.3423	27.9828	LDS 3219	0.52	0.44	1.08	0.55	1	2
15.5773	0.4275	CBL 205	1.04	0.42	1.44	0.76	2	4
16.1629	32.4891	LDS 3227	0.83	0.38	1.15	0.58	1	3
16.7226	23.6802	NEW	1.30	0.68	1.70	0.87	4	5
18.1427	-4.7024	LDS 3245	1.37	0.76	1.67	0.93	4	5
19.3855	25.4217	NEW	1.51	0.94	1.33	0.81	5	4
19.8912	24.8322	CBL 209	0.94	0.49	1.00	0.52	2	2
19.9617	25.4935	SLW 63	0.76	0.39	1.30	0.66	1	3
20.1468	6.7028	LDS 3265	0.70	0.43	0.93	0.55	1	2
20.2545	23.9330	LDS 877	0.67	0.32	1.57	0.45	0	3
20.6151	34.8650	NEW	1.29	0.69	1.56	0.81	4	5
20.8470	1.8699	NEW	1.20	0.60	1.27	0.64	3	3
20.9674	0.8304	GWP 182	1.45	0.78	1.48	0.79	4	4
21.2060	39.7912	NEW	1.20	0.62	1.55	0.82	3	5
21.2129	18.0431	LDS 3274	0.63	0.35	0.81	0.51	0	2
21.6531	0.6252	CLZ 8	1.65	0.90	1.92	1.00	5	6
21.8609	-8.9215	GWP 191	0.82	0.46	0.89	2.56	1	5
23.2800	-6.0364	LDS 3290	1.50	0.80	1.53	0.81	5	5
24.2903	-3.0913	GWP 203	1.25	0.66	1.82	0.99	3	6
25.3499	32.2633	LDS 1111	1.22	0.64	1.21	0.65	3	3
25.8692	15.6464	NEW	0.62	0.37	0.96	0.56	0	2
25.9382	-17.1922	NEW	1.71	0.90	1.72	0.90	5	5
25.9454	19.9057	GWP 216	1.09	0.57	1.12	0.58	3	3
26.4582	20.9601	AZC 15	1.56	0.67	2.03	0.94	4	6
26.4965	21.0957	LDS 3308	1.32	0.69	1.45	0.79	4	4
26.9896	-6.8728	NEW	1.07	0.56	1.28	0.68	3	4
27.1030	28.3934	NEW	1.36	0.71	2.02	1.03	4	6
27.2776	6.4010	LDS 3315	0.82	0.39	0.67	0.37	1	1
27.3071	65.0911	NEW	0.61	0.38	0.81	0.49	0	2
27.3238	18.1271	GWP 225	1.01	0.56	1.37	0.76	2	4
27.5833	11.7723	GWP 227	0.77	0.45	0.93	0.49	1	2
27.9165	-18.8276	LDS 1119	0.86	0.40	1.43	0.72	1	4
28.1953	64.4091	NEW	0.56	0.35	0.76	0.52	0	2
28.4826	29.5325	AZC 18	1.33	0.76	1.28	0.70	4	4
29.0487	-3.1614	UC 648	0.49	1.09	1.02	0.56	3	2
29.1263	65.7435	NEW	0.68	0.44	0.69	0.36	1	1
29.4425	24.6173	NEW	0.91	0.50	1.36	0.70	2	4
29.4645	16.2257	CBL 11	0.95	0.52	1.15	0.63	2	3
29.4920	62.3444	NEW	0.66	0.42	0.84	0.47	1	2
29.7619	29.6839	AZC 19	1.32	0.72	1.39	0.77	4	4
30.2393	-5.1792	LDS 5361	0.58	0.32	1.29	0.70	0	4
30.2677	-17.6834	LDS 5362	0.76	0.43	1.05	0.63	1	3
30.4752	67.1517	NEW	1.14	0.63	1.01	0.59	3	3
30.5441	-18.1415	GWP 252	1.45	0.75	1.73	0.93	4	5
30.8484	8.8319	NEW	1.07	0.53	1.35	0.66	2	4
30.8662	62.3385	NEW	0.58	0.32	1.25	0.72	0	4
30.9631	2.6808	LDS 3341	1.16	0.57	1.54	0.75	3	4
31.6560	-7.1281	LDS 5366	1.45	0.67	1.68	0.87	4	5

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	NAME	PRIMARY		SECONDARY		TYPE M+	TYPE M+
			(r-i)	(i-z)	(r-i)	(i-z)		
32.9871	16.9943	LDS 3355	1.34	0.72	1.57	0.85	4	5
33.1654	16.2350	GWP 270	1.26	0.63	1.41	0.72	3	4
33.3434	31.9227	NEW	1.26	0.67	1.29	0.68	3	4
33.6098	-11.0742	LDS 5373	0.54	0.32	0.64	0.37	0	1
34.3465	70.7603	CBL 210	1.07	0.58	1.47	0.77	3	4
35.0575	5.5767	CBL 211	0.87	0.49	0.99	0.54	2	2
35.8361	22.5007	LDS 3378	0.64	0.32	1.43	0.73	0	4
35.9285	25.0468	LDS 3379	1.35	0.63	1.27	0.66	3	3
35.9810	-9.3842	LDS 5382	1.17	0.78	1.39	0.74	4	4
38.1240	6.1042	FMR 55	0.88	0.47	1.66	0.84	2	5
38.1830	74.1485	CBL 212	0.74	0.45	0.85	0.52	1	2
38.2552	1.0940	CBL 213	1.38	0.79	1.45	0.82	4	4
38.8032	21.0488	SLW 120	1.22	0.67	1.38	0.73	3	4
39.2101	20.2111	SLW 123	0.85	0.49	1.41	0.74	2	4
40.6041	2.7748	GWP 356	1.50	0.83	0.97	2.78	5	5
42.1294	32.7722	NEW	1.38	0.77	1.52	0.85	4	5
42.1814	-5.4392	UC 819	1.13	0.59	1.23	0.64	3	3
42.8408	-15.4281	GWP 382	1.52	0.85	1.53	0.84	5	5
43.9682	-15.3465	LDS 3441	0.66	0.38	0.65	0.40	1	1
44.6393	6.7659	SLW 140	1.27	0.66	1.63	0.86	3	5
44.9157	-14.5963	LDS 3445	0.55	0.64	1.25	0.66	2	3
46.6495	0.4298	CBL 218	1.24	0.63	1.40	0.75	3	4
50.0486	77.9747	SLW 152	1.36	0.67	1.56	0.74	4	4
50.2429	-0.9275	LDS 5420 AB	0.53	0.29	1.09	0.57	0	3
52.3878	42.8563	NEW	0.76	0.42	1.54	0.82	1	5
52.7922	42.0576	BVD 189	1.36	0.74	1.36	0.75	4	4
57.2477	50.0645	NEW	1.81	0.97	1.87	0.99	6	6
57.3275	-12.0376	NEW	0.61	0.38	1.49	0.82	0	5
59.0668	52.1353	NEW	0.73	0.62	0.81	0.48	2	2
59.3143	-10.9015	GWP 536	1.12	0.61	1.35	0.74	3	4
59.9129	-11.7903	GWP 540	1.46	0.76	1.58	0.82	4	5
60.3484	1.1136	GWP 542	1.68	0.90	2.17	1.17	5	7
60.7972	-0.4043	NEW	0.78	0.48	0.66	0.40	1	1
62.5362	-4.2097	NEW	0.69	0.38	0.93	0.49	1	2
62.5964	16.1847	GWP 557	0.76	0.43	1.30	0.68	1	4
64.3080	29.2129	NEW	1.21	0.64	1.47	0.78	3	4
64.4973	52.9498	NEW	0.53	0.28	1.87	0.89	0	6
64.9543	32.1998	NEW	1.09	0.63	1.44	0.82	3	4
65.2939	6.4451	SLW 171	1.27	0.66	1.38	0.73	3	4
65.7116	54.5303	NEW	0.62	0.60	0.80	0.60	2	2
66.6478	19.1939	GWP 585	1.05	0.31	0.98	0.59	1	2
67.5064	-1.0774	GWP 592	0.91	0.50	1.54	0.84	2	5
67.5265	9.0411	CBL 225	0.48	0.31	0.60	0.36	0	0
68.2832	-0.7446	GWP 596	1.16	0.58	1.44	0.74	3	4
69.5509	-7.6016	NEW	1.40	0.74	1.47	0.77	4	4
71.1993	-0.0085	GWP 611	0.68	0.42	0.79	0.48	1	1
71.4396	58.0921	NEW	0.64	0.46	0.74	0.58	1	2
72.0206	59.6764	CBL 226	0.89	0.51	0.88	0.52	2	2
72.4602	-6.4204	NEW	1.49	0.77	1.54	0.81	4	5
72.5439	-4.2093	SLW 172	1.36	0.71	1.43	0.74	4	4

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

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			(r-i)	(i-z)	(r-i)	(i-z)		
74.4233	26.1747	LDS 6152	0.89	0.42	1.30	0.69	1	4
75.9398	-3.2587	SLW 178	1.47	0.81	1.54	0.86	5	5
77.7073	-2.0041	NEW	0.69	0.42	0.85	0.51	1	2
80.2154	26.6981	AZC 43	1.11	0.59	1.13	0.60	3	3
80.7033	28.0082	NEW	0.63	0.37	0.49	0.41	0	0
80.9712	28.4175	IPH 13	0.71	0.41	1.10	0.59	1	3
82.6950	-0.5675	CBL 228	1.25	0.69	1.56	0.89	4	5
82.7899	63.3446	CBL 229	0.96	0.51	1.45	0.77	2	4
83.2143	3.4040	NEW	1.52	0.78	1.40	0.73	4	4
83.7654	3.6155	NEW	0.69	0.42	1.91	1.01	1	6
85.8302	3.5375	NEW	0.71	0.49	0.57	0.38	1	0
87.0119	22.0589	NEW	0.46	0.33	1.18	0.69	0	3
89.5894	22.0736	NEW	0.62	0.43	0.63	0.57	1	1
91.7696	63.4211	NEW	1.50	0.77	1.88	0.93	4	6
93.2852	5.3769	GWP 764	1.32	0.74	1.48	0.80	4	4
93.9610	44.4394	NEW	1.27	0.69	1.25	0.70	4	4
95.0016	34.6970	NEW	1.65	0.96	1.69	1.02	5	6
97.3074	7.8459	IPH 24	1.43	0.77	1.45	0.84	4	5
100.1133	64.2539	CBL 233	0.81	0.43	1.18	0.63	1	3
101.0817	10.3339	LDS 5680	0.60	0.52	0.85	0.42	1	1
105.1090	37.5503	NEW	0.55	0.30	1.68	0.90	0	5
106.8448	66.2761	NEW	1.13	0.62	1.86	1.00	3	6
107.3515	31.3240	NEW	1.38	0.72	1.55	0.80	4	5
110.4190	35.8510	SLW 192	1.56	0.83	1.85	1.03	5	6
110.7781	14.1111	GWP 901	0.90	1.33	1.73	0.96	5	6
111.9617	42.4719	CBL 234	1.46	0.77	1.65	0.90	4	5
112.0865	31.0035	CBL 235	0.83	0.58	1.49	0.78	2	4
113.9183	27.8237	CBL 236	1.10	0.60	1.34	0.73	3	4
115.7318	66.4950	NEW	0.70	0.61	1.39	0.75	2	4
115.7945	42.8767	NEW	0.65	0.34	2.06	1.06	0	7
116.0562	37.6648	NEW	1.54	0.54	1.64	0.88	3	5
116.4990	44.6468	NEW	0.95	0.54	1.08	0.74	2	3
117.8786	-9.2879	NEW	0.97	0.53	2.19	0.43	2	4
118.2084	82.6954	SLW 210	1.12	0.61	1.17	0.62	3	3
119.1866	46.3326	SLW 214	1.26	0.66	1.27	0.66	3	3
119.7087	46.4449	CBL 238	1.09	0.60	1.37	0.73	3	4
121.5498	35.7325	NEW	0.87	0.50	1.36	0.75	2	4
121.6154	42.5302	SLW 219	1.08	0.60	1.24	0.71	3	4
121.9631	65.2387	LDS 2561	1.49	0.80	1.55	0.84	5	5
122.3855	54.1074	NEW	0.50	0.28	1.44	0.80	0	4
122.4947	7.9378	NEW	0.56	0.31	1.63	0.84	0	5
122.7108	53.6292	NEW	1.25	0.71	1.36	0.76	4	4
123.4082	29.5494	NEW	0.85	0.54	1.25	0.77	2	4
123.5535	14.1471	CBL 245	0.86	0.41	1.38	0.69	1	4
123.8913	29.8493	SLW 230	1.25	0.67	1.33	0.72	3	4
124.2610	55.0623	SLW 231	1.05	0.60	1.12	0.62	3	3
124.6412	31.6339	NEW	0.76	0.56	1.25	0.66	2	3
125.1800	-0.0155	SLW 241	1.20	0.63	1.34	0.73	3	4
125.9202	14.5367	LDS 1211	1.03	0.56	1.39	0.85	2	4
126.0429	-1.8337	GWP 1014	0.94	0.49	1.50	0.82	2	5

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			(r-i)	(i-z)	(r-i)	(i-z)		
126.0723	-4.4038	GWP 1015	0.77	0.42	1.34	0.70	1	4
126.7865	32.9944	NEW	1.71	0.96	1.72	0.94	6	5
127.0938	0.4361	LDS 3793	0.84	0.48	0.98	0.53	2	2
127.1317	27.6510	NEW	1.45	0.79	1.74	0.93	4	5
127.4853	47.1119	GRV 1005	0.66	0.32	0.92	0.46	0	2
127.9852	18.5763	LDS 1215	0.89	0.50	1.27	0.64	2	3
128.1922	4.8981	GWP 1036	1.20	0.67	1.52	0.83	3	5
128.4603	20.2201	NEW	1.37	0.29	1.24	0.68	2	3
128.4661	24.4369	CBL 260	1.41	0.74	1.87	0.98	4	6
129.4731	31.7043	LDS 3802	0.63	0.32	1.62	0.83	0	5
130.0760	47.6603	NEW	1.46	0.75	1.49	0.75	4	4
130.3365	1.1579	LDS 3807	1.26	0.63	1.36	0.69	3	4
130.6014	58.4335	SLW 282	0.55	0.33	0.95	0.54	0	2
130.9752	58.4797	CBL 266	0.86	0.61	1.22	0.61	2	3
130.9827	14.2193	NEW	0.70	0.39	1.22	0.64	1	3
131.1456	49.2003	SLW 286	0.75	0.40	1.08	0.56	1	3
131.2634	14.9010	NEW	0.60	0.37	1.08	0.60	0	3
131.5521	7.7396	LDS 3817	0.81	0.51	1.53	0.80	2	5
131.5803	50.3219	SLW 290	0.69	0.42	1.23	0.68	1	3
131.6001	24.0368	CBL 267	1.19	0.67	1.31	0.73	3	4
131.9749	43.0445	NEW	0.86	0.45	1.44	0.71	2	4
132.2878	56.0776	LDS 3820	1.12	0.57	2.49	1.33	3	8
132.3778	60.0379	LDS 1219	1.34	0.63	1.58	0.74	3	4
132.6098	42.2155	NEW	1.04	0.59	0.97	0.52	3	2
133.0240	32.7813	SLW 308	1.32	0.68	1.48	0.77	4	4
133.3336	48.6003	BVD 203	1.34	0.70	1.55	0.85	4	5
133.4041	55.5337	GRV 1012	0.94	0.47	1.11	0.56	2	3
134.6606	4.4862	SLW 318	1.11	0.55	1.14	0.59	3	3
134.9539	18.5543	NEW	1.65	0.98	2.11	1.13	5	7
135.9097	44.9843	BVD 206	0.61	0.28	1.25	0.67	0	3
136.5376	12.3807	GWP 1136	0.73	0.39	0.90	0.52	1	2
137.9730	64.5921	NEW	0.64	0.40	1.20	0.66	1	3
138.0561	28.6351	CBL 274	0.53	0.32	0.67	0.38	0	1
139.0599	6.1589	SLW 339	0.78	0.41	1.04	0.52	1	2
139.4385	53.2153	LDS 3869	0.77	0.39	1.43	0.80	1	4
139.6849	17.1915	NEW	1.83	0.96	1.92	1.02	6	6
140.3947	26.9298	AZC 62	1.04	0.49	0.87	0.49	2	2
140.5475	34.0574	CRB 81	0.97	0.53	0.97	0.52	2	2
141.2885	36.7066	CRB 82	0.50	0.29	1.22	0.64	0	3
141.6457	45.7897	CBL 278	0.51	0.28	1.33	0.69	0	4
141.9756	28.6393	CBL 279	0.63	0.43	1.36	0.76	1	4
142.6479	55.9815	NEW	1.35	0.72	1.72	0.90	4	5
143.1430	55.1921	NEW	1.21	0.63	1.24	0.66	3	3
143.6459	15.2116	SLW 369	1.34	0.70	1.36	0.73	4	4
143.8819	15.2363	CBL 285	1.22	0.63	1.21	0.65	3	3
144.8106	30.2452	LDS 3909	0.51	0.28	1.11	0.62	0	3
145.1421	59.2459	LDS 1230	1.32	0.68	1.56	0.81	4	5
145.2355	46.1250	NEW	1.41	0.76	1.41	0.76	4	4
145.3156	7.1286	GWP 1212	1.25	0.67	1.35	0.72	3	4
146.2065	-2.9304	GWP 1229	0.70	0.36	1.53	0.82	1	5

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	NAME	PRIMARY		SECONDARY		TYPE M+	TYPE M+
			(r-i)	(i-z)	(r-i)	(i-z)		
146.3416	46.2759	LDS 3922	1.48	0.81	1.53	0.84	5	5
146.3549	3.7221	GWP 1232	1.66	0.86	1.85	1.00	5	6
147.0062	81.6037	NEW	0.61	0.31	1.40	0.73	0	4
147.2835	-0.8997	NEW	1.17	0.64	1.52	0.83	3	5
147.3219	4.0710	SLW 394	1.33	0.71	1.34	0.72	4	4
147.3345	20.7109	LDS 3932	0.93	0.47	1.81	0.40	2	3
147.6203	22.3703	AZC 63	1.42	0.78	1.39	0.73	4	4
147.6889	24.1602	NEW	0.91	0.50	1.24	0.64	2	3
148.2477	58.1898	NEW	0.80	0.37	0.89	0.40	1	1
148.8217	22.0523	NEW	0.54	0.33	0.54	0.34	0	0
149.0813	27.9690	UC 1845	1.40	0.73	1.36	0.72	4	4
149.1125	-1.9132	LDS 3944	1.25	0.69	1.52	0.89	4	5
149.4029	0.4876	NEW	0.60	0.34	1.32	0.72	0	4
149.4194	-1.1783	NEW	0.97	0.54	1.54	0.85	2	5
149.6509	11.8978	GWP 1263	1.03	0.57	1.47	0.78	2	4
150.4355	51.5774	NEW	0.82	0.52	1.44	0.84	2	5
150.6464	34.9509	NEW	0.70	0.41	1.35	0.71	1	4
150.9852	2.1271	GRV 1042	1.03	0.56	1.06	0.59	2	3
151.0052	19.1477	NEW	0.79	0.54	0.98	0.51	2	2
151.0743	47.5310	CBL 299	0.52	1.46	1.51	0.81	4	5
151.1729	43.0043	LDS 3953	1.20	0.69	1.39	0.76	3	4
151.9045	54.2666	NEW	0.89	0.46	1.16	0.64	2	3
151.9573	21.8394	NEW	0.97	0.53	1.27	0.70	2	4
152.1531	38.3227	SLW 438	1.22	0.62	1.26	0.65	3	3
152.3194	11.3648	GWP 1303	1.35	0.64	1.46	0.71	4	4
152.4093	40.6873	CBL 301	1.18	0.62	1.29	0.68	3	4
152.8377	27.3593	LDS 3961	1.72	0.93	1.76	0.93	5	6
153.1661	66.1619	NEW	1.44	0.80	1.62	0.90	4	5
153.6331	1.8860	CBL 306	1.09	0.65	1.29	0.68	3	4
153.8398	47.4380	UC 153	1.24	0.63	2.48	0.33	3	4
153.9910	11.3786	GWP 1333	1.01	0.53	1.16	0.61	2	3
154.1745	38.9387	LDS 3971	0.97	0.57	1.02	0.60	2	3
154.8019	13.3222	GWP 1345 BC	0.77	0.45	1.16	0.62	1	3
155.3613	25.6480	NEW	0.62	0.33	0.85	0.44	0	1
155.4594	35.9173	LDS 1240	1.27	0.72	1.36	0.78	4	4
155.5374	34.4506	CBL 307	1.11	0.56	1.29	0.68	3	4
155.6880	58.5974	SLW 9001	1.55	0.86	1.43	0.76	5	4
156.6538	62.7551	LDS 2583	1.40	0.72	1.41	0.73	4	4
156.7203	45.1841	SLW 473	1.31	0.66	1.48	0.76	4	4
157.6359	31.4971	NEW	1.17	0.64	1.40	0.78	3	4
158.3636	17.9975	NEW	0.75	0.48	1.00	0.63	1	3
158.5637	40.6830	LDS 3998	0.83	1.38	1.54	0.81	5	5
159.0221	29.1049	LDS 1248	1.06	0.57	0.99	0.51	3	2
159.1624	54.6806	LDS 2870	0.91	0.49	1.68	0.90	2	5
159.2800	51.3378	LDS 2871	0.93	0.50	1.46	0.70	2	4
159.5184	24.6950	SLW 500	0.99	0.54	1.20	0.64	2	3
159.6264	12.1666	GWP 1417	0.98	0.48	1.77	0.91	2	5
159.7034	6.0255	LDS 2875	0.48	0.28	1.04	0.59	0	3
159.9180	32.4518	DAM 28	0.83	0.36	1.85	0.58	1	4
160.3248	21.9051	AZC 65	1.31	0.70	1.27	0.67	4	3

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	NAME	PRIMARY		SECONDARY		TYPE M+	TYPE M+
			(r-i)	(i-z)	(r-i)	(i-z)		
161.1572	65.8421	NEW	0.89	0.52	1.45	0.78	2	4
161.2427	61.2439	LDS 2586	0.76	0.46	1.36	0.71	1	4
161.8387	33.8267	CRB 85	1.08	0.56	1.43	0.76	3	4
162.2172	-1.0379	GWP 1465	1.06	0.60	1.18	0.65	3	3
162.5800	-22.5686	LDS 4024	1.29	0.64	1.35	0.69	3	4
162.7791	24.5540	NEW	0.68	0.37	1.39	0.74	1	4
162.8541	-20.8813	NEW	1.47	0.77	1.75	0.93	4	5
163.2244	23.0184	NEW	1.69	0.97	1.66	0.93	6	5
163.5905	26.9390	SLW 538	1.05	0.55	1.29	0.67	2	4
164.1451	58.9921	LDS 2589	1.16	0.63	1.26	0.69	3	4
164.4492	-1.1188	GWP 1509	0.64	0.32	0.99	0.53	0	2
164.4949	10.0343	NEW	1.43	0.76	1.94	0.98	4	6
164.9008	12.6671	LDS 4043	0.87	0.99	1.69	0.89	4	5
164.9447	22.7130	CBL 324	1.56	0.82	1.60	0.82	5	5
164.9983	13.7466	GWP 1516	1.21	0.62	1.66	0.84	3	5
165.0335	75.7973	NEW	1.22	0.65	1.30	0.69	3	4
165.1309	64.2894	GRV 1050	2.30	0.36	1.19	0.67	4	3
165.5079	23.8855	CBL 326	1.59	0.32	1.14	0.70	2	3
165.5557	46.0724	SLW 555	1.19	0.66	1.43	0.79	3	4
165.7347	55.4758	NEW	1.11	0.45	1.40	0.74	2	4
166.1409	63.0615	NEW	0.91	0.49	1.16	0.64	2	3
166.5567	47.4351	GRV 1192	0.67	1.33	1.72	0.96	4	6
166.8162	31.7627	NEW	1.09	0.64	1.31	0.74	3	4
167.0888	47.8605	BVD 216	0.88	0.36	1.51	0.85	1	5
167.3230	54.3821	NEW	1.03	0.54	0.94	0.45	2	2
167.4628	47.6190	CBL 330	0.52	0.29	1.29	0.67	0	4
167.4965	-2.8093	UC 2092	1.02	0.56	1.24	0.67	2	3
167.9294	58.0516	UC 2097	0.48	0.30	0.55	0.33	0	0
167.9491	32.2973	NEW	0.57	0.29	1.61	0.87	0	5
168.7687	23.7046	AZC 69	1.47	0.73	1.38	0.65	4	4
168.8277	18.8524	GWP 1564	1.40	0.68	1.60	0.84	4	5
168.9197	59.3823	SLW 582	1.26	0.65	1.26	0.65	3	3
168.9293	0.7805	GWP 1567	0.92	0.44	1.22	0.62	2	3
169.8378	23.6848	AZC 70	1.24	0.66	1.19	0.64	3	3
170.0507	25.4726	CBL 337	1.18	0.65	1.26	0.73	3	4
170.0734	7.1150	NEW	0.80	0.44	1.12	0.60	1	3
171.1441	20.4038	NEW	0.58	0.32	0.82	0.48	0	2
171.1513	34.9757	LDS 4095	0.62	0.35	2.05	0.50	0	4
171.3307	74.5472	SLW 599	1.22	0.61	1.40	0.71	3	4
171.6865	25.0545	CBL 340	0.68	3.34	1.53	0.78	2	4
172.3154	39.5277	SLW 607	0.50	0.32	0.90	0.52	0	2
173.3764	33.1415	CBL 344	0.69	0.39	1.47	0.83	1	5
173.4052	7.6400	NEW	1.35	0.74	1.32	0.71	4	4
173.4548	14.5576	GWP 1609	0.76	0.43	1.32	0.72	1	4
174.2693	39.7942	NEW	1.42	0.77	1.44	0.77	4	4
174.5784	61.2106	LDS 2605	1.01	0.53	1.03	0.53	2	2
174.7520	4.1059	GRV 1059	1.07	0.60	1.10	0.61	3	3
174.9084	21.0792	NEW	1.22	0.65	1.24	0.66	3	3
175.8591	9.6778	SLW 636	0.78	0.45	1.23	0.71	1	4
175.9255	54.9623	CBL 350	0.64	0.37	1.02	0.56	0	2

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

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			(r-i)	(i-z)	(r-i)	(i-z)		
176.5905	30.9614	SLW 645	1.07	0.54	1.13	0.56	2	3
176.7381	20.9385	CBL 357	0.66	0.38	0.68	0.40	1	1
177.4709	5.2841	NEW	0.58	0.33	0.80	0.41	0	1
178.0810	38.4354	LDS 4151	1.34	0.68	1.40	0.72	4	4
179.4062	64.1585	NEW	1.06	0.73	1.51	0.87	3	5
179.4238	43.3370	BVD 219	0.81	0.58	1.10	0.59	2	3
179.9736	11.7341	BPM 585	0.78	0.41	0.84	0.45	1	1
180.0686	6.2962	GRV 1196	1.30	0.68	1.47	0.79	4	4
180.3611	2.0520	NEW	0.82	0.42	1.58	0.86	1	5
180.5532	24.0432	SLW 678	1.30	0.67	1.50	0.81	4	5
180.6561	44.2993	BVD 221	1.43	0.74	1.79	1.01	4	6
180.7327	0.0682	GRV 1068	1.43	0.33	0.95	0.53	2	2
181.0907	63.0134	CBL 371	1.00	0.48	1.47	0.75	2	4
181.2457	21.8241	LDS 4177	1.17	0.72	1.14	0.63	3	3
181.7197	39.3493	SLW 684	0.69	0.37	0.72	0.40	1	1
181.9031	15.5508	LDS 4181	0.96	0.53	1.22	0.68	2	3
182.2479	3.9486	NEW	1.01	0.55	1.54	0.86	2	5
182.8738	47.4208	LDS 4187	0.73	0.30	1.25	0.66	0	3
183.0093	38.8194	LDS 4188	0.59	0.33	1.39	0.76	0	4
183.6073	27.4000	LDS 1286	1.00	0.54	1.00	0.55	2	2
183.7332	58.4954	NEW	1.38	0.42	1.39	0.79	3	4
183.7632	39.2404	LDS 4196	1.36	0.74	2.49	1.35	4	8
183.7653	48.9629	SLW 697	0.88	0.46	1.01	0.51	2	2
184.4923	27.8577	CBL 378	0.67	0.28	1.64	0.92	0	5
184.9587	34.5398	SLW 708	1.36	0.73	1.46	0.79	4	4
184.9656	0.0874	GRV 1075	0.68	0.41	0.98	0.54	1	2
185.8189	66.7608	CBL 381	1.01	0.55	1.60	0.94	2	5
185.9511	-1.9375	SLW 714	1.08	0.60	1.41	0.77	3	4
186.3220	49.6331	NEW	0.91	0.45	1.44	0.74	2	4
186.6484	38.9523	LDS 4208	0.68	0.41	0.62	0.38	1	1
188.0576	41.0457	UC 177	1.06	0.49	1.10	0.59	2	3
188.2814	36.2395	CRB 92	1.06	0.54	1.25	0.63	2	3
188.3522	14.2633	LDS 1319	0.96	0.52	1.45	0.86	2	5
188.5666	0.8583	SLW 736	1.32	0.72	1.43	0.77	4	4
188.6668	19.8581	NEW	1.01	0.56	1.26	0.69	2	4
188.7742	1.0875	NEW	0.59	0.30	0.72	0.42	0	1
188.8861	17.8713	CBL 387	0.84	0.46	1.35	0.67	1	4
189.0135	62.4957	LDS 2654	0.72	1.12	1.62	0.83	4	5
189.0556	14.9546	CBL 388	1.17	0.61	1.47	0.80	3	4
189.0842	11.5046	LDS 1327	0.62	0.35	0.68	0.40	0	1
189.1800	1.8364	SLW 744	1.34	0.72	1.35	0.74	4	4
189.3303	-0.2514	SLW 747	0.82	0.48	1.07	0.63	2	3
190.0970	-17.0777	NEW	0.91	0.49	1.76	0.94	2	6
190.1489	22.3836	LDS 4246	0.91	0.48	1.21	0.64	2	3
190.1797	46.4487	CBL 391	1.25	0.61	1.53	0.78	3	4
190.4392	21.5289	SLW 760	0.76	0.47	1.31	0.73	1	4
190.5172	52.4632	LDS 3055	1.41	0.78	1.46	0.81	4	4
191.3313	3.3217	NEW	0.59	1.30	1.77	0.95	4	6
191.4615	63.3324	LDS 2658	1.04	0.55	1.10	0.57	2	3
192.0367	22.0701	AZC 77	1.18	0.73	2.05	1.08	4	7

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

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			(r-i)	(i-z)	(r-i)	(i-z)		
192.4695	26.7179	LDS 4280	0.59	0.37	0.88	0.55	0	2
193.0343	37.9245	SLW 786	1.16	0.61	1.52	0.80	3	5
193.5231	55.0090	LDS 3067	0.90	0.46	0.99	0.51	2	2
193.9053	6.3477	LDS 4295	1.64	0.87	1.71	0.91	5	5
194.1641	31.0447	CBL 401	1.40	0.67	1.62	0.83	4	5
194.2971	1.6815	GRV 1200	0.46	0.34	0.95	0.55	0	2
194.3340	30.7575	LDS 1347	1.43	0.75	1.54	0.79	4	5
195.1255	28.9943	NEW	0.69	0.42	0.87	0.51	1	2
195.1312	46.1346	LDS 4305	0.77	0.46	1.26	0.66	1	3
195.8438	43.5609	SLW 817	1.41	0.80	1.49	0.85	4	5
195.9583	32.1669	NEW	0.75	0.39	0.82	0.43	1	1
195.9959	22.8214	NEW	1.38	0.72	1.27	0.67	4	3
196.3467	12.0039	LDS 4313	1.37	0.75	1.32	0.71	4	4
196.8016	44.5019	LDS 4317	1.39	0.74	1.60	1.05	4	6
197.0658	8.2130	CBL 408	1.34	0.67	1.36	0.69	4	4
197.1407	14.4086	LDS 4320	1.14	0.62	1.17	0.66	3	3
197.5889	32.8829	CBL 410	1.25	0.68	1.71	0.91	3	5
197.6643	7.2391	CBL 411	0.81	1.37	1.41	0.70	5	4
197.7023	47.0355	BVD 227	1.13	0.65	1.19	0.68	3	3
198.3784	16.9411	SLW 837	1.47	0.77	1.49	0.80	4	4
198.9568	36.1892	NEW	2.04	0.48	1.31	0.71	4	4
199.1036	43.0946	UC 2509	1.14	0.62	1.10	0.59	3	3
199.3243	21.2879	LDS 2910	1.50	0.81	1.83	1.04	5	6
199.4381	51.5277	NEW	0.90	0.47	1.53	0.78	2	4
199.5646	47.5082	SLW 850	1.40	0.81	1.90	1.06	4	6
199.7980	10.3285	NEW	0.86	0.45	0.89	0.47	1	2
199.9135	28.3727	LDS 1383	0.98	0.58	1.16	0.67	2	3
200.0329	61.0578	LDS 2673	0.91	0.48	1.43	0.74	2	4
200.0973	6.8900	NEW	1.83	1.00	1.65	0.81	6	5
200.1704	-3.4412	NEW	0.60	0.34	1.02	0.57	0	2
200.2492	43.4603	SLW 859	0.85	0.50	0.97	0.57	2	2
200.5319	67.8116	GRV 1087	0.78	0.44	0.86	0.48	1	2
200.5657	5.5216	CBL 422	0.56	0.30	0.85	0.51	0	2
200.6474	16.7131	NEW	1.26	0.67	1.29	0.67	3	4
200.7787	50.5509	SLW 864	1.15	0.59	1.17	0.63	3	3
200.9903	35.8226	NEW	0.56	0.31	0.56	0.36	0	0
201.1590	-1.8925	LDS 4357	1.45	0.76	1.72	0.89	4	5
201.2742	51.8829	SLW 866	1.04	0.54	1.19	0.60	2	3
201.3889	22.8945	SLW 867	1.51	0.79	1.55	0.80	4	5
201.4041	43.7438	CBL 425	1.13	0.57	1.20	0.64	3	3
202.0177	28.1319	LDS 1389	1.12	0.57	1.38	0.70	3	4
202.4715	26.7921	AZC 79	1.46	0.81	1.33	0.71	4	4
202.5916	38.7492	CRB 98	0.83	0.47	1.24	0.63	1	3
203.0408	7.7375	LDS 3074	0.79	0.44	1.21	0.65	1	3
203.2673	38.2188	CBL 427	0.69	0.58	1.30	0.72	2	4
203.4448	19.2795	SLW 892	0.92	0.49	1.16	0.63	2	3
203.5417	67.2625	LDS 2323	1.26	0.63	1.49	0.76	3	4
204.0681	33.7085	LDS 4380	2.24	0.35	1.19	0.62	4	3
204.2369	7.8653	VBS 23	1.13	0.59	1.53	0.78	3	5
204.6930	1.7806	NEW	1.01	0.57	2.15	1.14	2	7

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			(r-i)	(i-z)	(r-i)	(i-z)		
205.1350	33.2328	NEW	0.57	0.32	0.75	0.41	0	1
205.5331	67.3888	LDS 2325	1.02	0.54	1.37	0.74	2	4
205.6732	21.6020	NEW	0.82	0.47	1.17	0.35	2	2
206.3581	28.9566	LAW 20	1.20	0.61	1.36	0.65	3	4
206.6125	38.7296	SLW 927	1.18	0.65	1.38	0.72	3	4
206.7724	5.9257	LDS 3102	1.44	0.77	1.59	0.89	4	5
206.9649	40.3297	NEW	1.64	0.84	1.93	1.02	5	6
207.0033	33.7421	LDS 4408 AB	1.85	0.29	1.15	0.62	3	3
207.1643	29.0224	AZC 80	0.57	0.29	1.01	0.51	0	2
207.6703	-1.0116	NEW	1.21	0.63	1.55	0.82	3	5
208.2497	7.2811	NEW	0.50	0.29	1.68	0.86	0	5
208.5162	16.5197	CBL 433	0.70	0.37	0.83	0.44	1	1
208.7155	51.4710	CBL 434	0.92	0.48	1.63	0.82	2	5
209.2614	34.0585	NEW	1.47	0.84	1.30	0.73	5	4
209.3122	19.8819	SLW 948	1.33	0.68	1.51	0.78	4	4
209.4516	24.7934	CBL 435	1.03	0.54	1.24	0.67	2	3
209.7437	5.5149	SLW 953	0.93	0.50	1.00	0.52	2	2
209.8168	8.0023	NEW	1.20	0.64	1.54	0.84	3	5
210.4113	59.2369	LDS 2697	0.48	0.29	0.58	0.37	0	0
210.7794	24.3858	SLW 958	1.38	0.74	1.69	0.93	4	5
211.4265	15.6192	BPM 613	1.03	0.60	0.95	0.57	3	2
211.6036	11.6077	LDS 4432	1.30	0.72	1.41	0.79	4	4
211.8991	53.3696	LDS 2922	0.76	0.45	1.30	0.74	1	4
212.0121	-16.0398	NEW	0.65	0.33	1.49	0.75	0	4
213.4627	29.4634	SLW 982	1.27	0.62	1.26	0.69	3	4
213.6376	-1.2288	UC 2711	0.74	0.40	1.02	0.53	1	2
213.7498	2.3744	GRV 1096	0.85	0.45	1.49	0.83	1	5
213.8628	25.1775	NEW	0.94	0.50	1.28	0.66	2	3
213.8946	48.1117	CBL 445	0.98	0.48	1.38	0.72	2	4
213.9989	5.5835	NEW	1.28	0.71	1.24	0.81	4	4
214.2937	16.7649	SLW 988	1.12	0.57	1.37	0.68	3	4
214.3429	13.5011	LDS 4452	0.77	0.40	0.86	0.44	1	1
214.9838	16.5603	CBL 450	1.14	0.64	1.56	0.91	3	5
215.1114	35.3920	NEW	1.53	0.83	1.61	0.88	5	5
215.7237	-20.6428	NEW	1.16	0.62	1.26	0.71	3	4
215.7887	22.7211	LDS 4462	0.76	0.55	1.10	0.61	2	3
216.1134	59.2281	NEW	1.16	0.62	1.22	0.64	3	3
216.1498	18.0704	CBL 453	1.18	0.56	1.55	0.75	3	4
216.2367	57.8993	NEW	1.21	0.65	1.53	0.83	3	5
216.7367	55.6577	CBL 454	1.26	0.66	1.37	0.72	3	4
216.8442	3.2304	SLW 9005	1.38	0.69	1.46	0.73	4	4
216.9200	26.2263	AZC 85	1.23	0.63	1.28	0.65	3	3
217.0552	10.2225	CBL 455	1.21	0.66	1.39	0.73	3	4
217.0786	54.7091	LDS 4468	0.88	0.43	1.59	0.81	1	5
217.4426	34.7590	LDS 4470	1.04	0.57	1.16	0.64	3	3
217.4493	42.2564	SLW 1002	0.87	0.47	1.40	0.73	2	4
217.7336	13.0201	CBL 456	1.00	0.53	1.21	0.66	2	3
217.9205	6.4495	NEW	0.78	0.42	1.13	0.63	1	3
218.1465	-1.3872	NEW	1.00	0.55	1.10	0.58	2	3
218.9413	4.9698	CBL 461	0.98	0.54	1.02	0.55	2	2

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	NAME	PRIMARY		SECONDARY		TYPE M+	TYPE M+
			(r-i)	(i-z)	(r-i)	(i-z)		
218.9590	0.7096	CBL 462	1.00	0.50	1.29	0.71	2	4
219.8853	51.9061	LDS 4487	1.17	0.58	1.38	0.69	3	4
220.5172	16.8932	CBL 465	0.93	0.52	0.97	0.51	2	2
220.5792	26.2453	LDS 4490	1.26	0.66	1.53	0.80	3	5
220.6966	28.1224	CBL 466	1.01	0.28	0.65	0.36	1	0
221.4351	26.6369	NEW	1.32	0.75	1.57	0.91	4	5
221.9265	34.6576	NEW	0.70	0.38	1.29	0.71	1	4
222.0107	46.9666	SLW 1033	1.17	0.60	1.39	0.72	3	4
223.2703	53.9476	CBL 473	0.84	0.44	1.15	0.61	1	3
223.4139	7.3574	NEW	0.57	0.33	0.82	0.45	0	1
225.1837	40.1749	SLW 1051	1.52	0.80	1.62	0.89	5	5
225.1978	23.1075	LDS 4521	1.12	0.61	1.27	0.68	3	4
225.5044	60.9530	SLW 1053	1.00	0.54	1.00	0.54	2	2
225.8068	39.4541	SLW 1055	0.88	0.53	1.28	0.66	2	3
226.1840	22.5274	SLW 1057	0.77	0.44	1.46	0.80	1	4
227.0363	61.4387	NEW	0.59	0.33	1.78	0.92	0	6
227.5123	22.0986	NEW	0.85	0.50	1.02	0.60	2	3
228.1499	30.9517	CRB 109	0.48	0.28	0.90	0.48	0	2
228.3403	8.6389	CBL 481	0.63	0.38	1.04	0.58	0	3
228.8172	0.4073	NEW	1.28	0.70	1.29	0.72	4	4
228.9839	22.4085	NEW	0.78	0.43	1.55	0.76	1	4
229.3205	47.5232	GRV 1207	1.30	0.71	1.46	0.80	4	4
229.3452	35.9369	LDS 5165	1.07	0.71	1.62	0.90	3	5
229.7218	19.0649	UC 2982	0.75	0.37	2.72	0.84	1	7
230.1532	55.1371	CBL 486	0.63	0.36	1.24	0.68	0	3
230.3062	27.7479	LDS 4544	1.20	0.66	1.15	0.65	3	3
230.3599	53.2034	GRV 1209	1.20	0.67	1.23	0.69	3	3
230.8539	11.1754	NEW	0.90	0.45	0.93	0.46	2	2
231.2795	57.5020	NEW	0.66	0.35	1.21	0.63	0	3
231.2888	27.5664	AZC 90	0.87	0.49	1.31	0.72	2	4
231.4670	12.5347	CBL 488	0.66	0.38	1.15	0.59	1	3
231.5453	-2.8570	UC 3003	1.18	0.63	1.20	0.64	3	3
231.7055	27.3091	AZC 91	1.65	0.93	1.78	0.99	5	6
231.9668	49.1484	SLW 1095	1.42	0.78	1.67	0.91	4	5
232.0655	29.3386	NEW	0.89	0.54	1.00	0.60	2	3
232.9907	13.3573	LDS 4557	0.57	0.34	1.25	0.59	0	3
233.0902	56.9993	SLW 1103	1.71	0.90	1.78	0.94	5	6
233.5381	40.7901	LDS 4562	0.94	0.48	1.59	0.89	2	5
233.5712	63.8920	NEW	1.14	0.64	1.28	0.69	3	4
234.4683	0.2850	LDS 4575	0.89	0.52	0.88	0.49	2	2
234.9551	2.4947	NEW	0.73	0.38	1.41	0.72	1	4
235.8304	40.4027	CBL 494	1.61	0.44	1.44	0.77	3	4
236.3961	42.0852	UC 212	1.43	0.73	1.51	0.81	4	5
236.3975	18.9915	SLW 1135	1.58	0.90	1.69	0.97	5	6
236.4010	56.9842	NEW	0.92	0.46	1.16	0.57	2	3
236.8494	53.4087	NEW	1.03	0.61	1.59	0.90	3	5
237.0738	4.7261	SLW 1138	1.41	0.70	1.54	0.78	4	5
237.3033	45.0279	NEW	0.88	0.40	1.54	0.76	1	4
237.5326	18.3661	NEW	2.67	0.76	2.02	1.13	6	7
237.8183	6.3459	NEW	0.72	0.43	0.82	0.40	1	1

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	NAME	PRIMARY		SECONDARY		TYPE M+	TYPE M+
			(r-i)	(i-z)	(r-i)	(i-z)		
237.8183	6.3459	NEW	0.72	0.43	0.82	0.40	1	1
237.9101	61.1431	NEW	1.10	0.58	1.02	0.56	3	2
238.2828	22.8490	LDS 4598	2.11	0.56	1.97	1.00	5	6
238.5167	44.4289	LDS 1428	1.08	0.53	1.11	0.55	2	3
238.7548	35.2288	NEW	1.08	0.55	0.95	0.55	3	2
238.8730	15.7088	LDS 4602	1.12	0.61	1.46	0.78	3	4
238.8828	49.0735	NEW	1.58	0.83	1.64	0.87	5	5
238.9321	26.0516	LDS 4604	1.07	0.58	1.39	0.75	3	4
239.3731	3.4011	NEW	0.80	0.45	1.07	0.59	1	3
239.7728	51.7971	NEW	1.08	0.61	1.98	0.56	3	4
241.3093	-17.6722	LDS 4630	1.23	0.68	1.27	0.67	3	3
241.3806	29.9235	GRV 1217	1.09	0.58	1.40	0.75	3	4
241.7064	14.7358	NEW	0.52	0.30	1.25	0.68	0	3
242.4293	52.1786	NEW	0.50	0.28	1.10	0.54	0	3
242.8577	43.0924	NEW	1.36	0.67	1.41	0.70	4	4
242.9587	34.6981	NEW	0.57	0.37	1.47	0.81	0	4
243.5141	53.8250	LDS 4655	0.61	0.34	1.27	0.72	0	4
244.1729	22.7805	AZC 97	0.68	0.32	1.53	0.85	0	5
244.2595	-0.1013	NEW	0.65	0.37	1.62	0.85	1	5
244.8640	56.3326	NEW	0.64	0.33	0.71	0.36	0	1
245.4876	35.3981	NEW	1.49	0.85	1.43	0.81	5	4
245.8345	38.7316	LDS 4664	1.00	0.53	1.25	0.65	2	3
246.2437	-5.1642	NEW	1.31	0.80	1.57	0.93	4	5
246.8698	7.6775	NEW	1.26	0.71	1.47	0.83	4	5
248.0291	7.3279	NEW	0.53	0.29	1.03	0.58	0	2
248.3748	46.0599	BVD 247	1.00	0.57	1.08	0.62	2	3
249.1048	37.7952	LDS 4680	0.65	0.34	1.38	0.72	0	4
249.2637	12.2270	BPM 665	1.07	0.57	1.32	1.10	3	5
249.3832	53.8559	SLW 1188	0.89	0.47	0.83	0.46	2	1
249.5384	48.6414	SLW 1189	1.21	0.65	1.30	0.72	3	4
249.5767	50.6736	NEW	0.60	0.30	1.31	0.65	0	3
251.0388	37.8350	NEW	1.37	0.72	1.52	0.79	4	5
252.4825	79.5342	NEW	1.35	0.72	1.40	0.73	4	4
252.8689	18.2349	NEW	0.73	0.44	1.80	0.97	1	6
253.6643	50.8689	GRV 1223	1.37	0.68	1.35	0.62	4	3
255.1078	28.2857	LDS 4717	0.85	0.41	1.18	0.57	1	3
255.1082	23.7566	NEW	0.58	0.34	0.94	0.52	0	2
255.1260	33.2270	CBL 513	1.23	0.71	1.39	0.73	4	4
255.6099	11.7654	NEW	0.70	0.39	1.67	0.87	1	5
256.1921	73.0997	NEW	0.97	0.54	1.27	0.73	2	4
256.2522	28.1493	NEW	0.96	0.51	1.00	0.55	2	2
256.2693	59.4490	NEW	1.49	0.82	2.09	1.20	5	7
257.6061	27.9777	SKF 366	1.11	0.45	2.14	1.14	2	7
257.9359	-0.5620	LDS 4724	0.57	0.30	1.26	0.64	0	3
258.7007	43.1964	LDS 4731	1.22	0.60	1.28	0.63	3	3
259.0877	-2.1036	NEW	0.55	0.36	0.64	0.57	0	1
259.3079	36.0540	NEW	0.73	0.46	0.85	0.50	1	2
259.5219	27.0971	NEW	0.54	0.29	1.11	0.53	0	3
260.6460	29.5177	FMR 132	0.90	0.47	1.68	0.92	2	5
261.8348	33.9072	NEW	0.53	0.28	2.28	1.22	0	7
263.6019	4.9193	NEW	0.91	0.51	1.13	0.60	2	3

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

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			(r-i)	(i-z)	(r-i)	(i-z)		
263.8870	6.0532	NEW	1.13	0.57	1.62	0.87	3	5
264.1361	7.1297	UC 3374	1.18	0.62	1.39	0.74	3	4
264.4001	67.7244	NEW	1.49	0.78	1.41	0.72	4	4
264.7749	65.1519	NEW	1.07	0.77	1.67	0.93	3	5
264.9433	5.6246	FMR 137	0.56	0.32	0.62	0.35	0	0
265.0576	28.4391	NEW	1.23	0.67	1.30	0.68	3	4
266.7337	64.9359	LDS 2741	0.80	0.35	0.85	0.37	1	1
266.8601	44.1455	NEW	1.01	0.56	1.20	0.68	2	3
267.1462	46.0976	CBL 518	1.32	0.67	1.74	0.93	4	5
267.1944	5.6933	NEW	1.31	0.67	1.31	0.68	4	4
267.4790	41.8551	LDS 4765	1.39	0.82	1.38	0.82	4	4
269.2249	78.4767	NEW	1.07	0.59	0.97	0.54	3	2
269.3062	0.9325	NEW	0.75	0.28	0.69	0.47	0	1
269.6317	0.7237	NEW	0.66	0.33	0.46	0.54	0	1
270.2203	0.8416	NEW	0.47	0.81	1.39	0.86	2	4
272.8278	0.9743	NEW	0.75	0.35	0.73	0.45	1	1
274.2337	64.2448	SLW 1218	1.59	0.84	1.79	0.95	5	6
280.6273	-0.2593	NEW	1.67	1.15	1.79	1.32	6	7
281.5963	39.9721	LDS 4799	0.56	2.27	1.45	0.75	5	4
291.1071	14.7860	NEW	1.11	0.83	1.86	1.32	4	7
291.5741	15.4872	NEW	0.55	0.35	0.67	0.41	0	1
294.3393	63.3232	NEW	0.73	0.37	0.75	0.40	1	1
295.2510	23.2820	NEW	0.89	0.41	1.39	1.02	1	5
296.7048	62.6387	NEW	1.47	0.76	1.65	0.89	4	5
298.4580	10.3515	NEW	0.49	0.42	0.55	0.46	0	1
299.6021	60.5317	CBL 524	0.73	0.36	1.78	0.88	1	5
302.1205	60.3984	CBL 525	1.20	0.63	1.17	0.61	3	3
302.3434	33.1282	GIC 162	1.01	0.53	1.18	2.18	2	6
302.4844	41.9991	NEW	0.57	0.42	0.59	0.36	1	0
303.4920	7.2232	NEW	1.29	0.71	1.17	0.67	4	3
303.7531	32.7298	NEW	1.60	1.20	1.74	1.39	6	7
304.1702	8.0382	NEW	0.71	0.35	1.27	0.61	1	3
304.6610	-11.4369	NEW	1.09	0.71	1.82	0.86	3	5
306.7294	0.7565	NEW	1.30	0.71	1.42	0.80	4	4
307.4056	-5.5173	NEW	0.64	0.37	1.23	0.65	1	3
308.7576	-13.3905	NEW	1.03	0.54	1.33	0.69	2	4
309.0652	-13.3370	NEW	1.03	0.58	1.29	0.73	3	4
309.7707	27.1608	NEW	0.55	0.54	0.70	0.51	1	1
310.0914	-6.1701	NEW	0.54	0.50	1.07	0.60	1	3
311.5927	45.8478	NEW	0.61	0.49	0.69	0.46	1	1
312.0350	39.9707	NEW	0.56	0.37	0.94	0.57	0	2
312.0630	75.3106	LDS 1940	1.39	0.74	1.45	0.76	4	4
312.4928	57.8417	NEW	0.64	0.44	0.83	0.50	1	2
313.6640	42.1775	NEW	1.18	0.88	1.42	0.99	4	5
314.0111	-5.9222	UC 4333	0.50	1.17	1.16	0.62	3	3
314.3734	-11.7008	NEW	0.73	0.32	1.77	0.96	0	6
315.2225	-3.2735	NEW	0.49	0.30	1.24	0.68	0	3
315.5343	3.4863	NEW	0.62	0.44	1.58	0.88	1	5
315.8179	-17.6377	NEW	0.68	0.44	1.44	0.77	1	4
316.2584	-3.1529	NEW	1.52	0.70	1.58	0.85	4	5

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	NAME	PRIMARY		SECONDARY		TYPE M+	TYPE M+
			(r-i)	(i-z)	(r-i)	(i-z)		
317.2117	54.9814	NEW	0.55	0.47	0.69	0.50	1	1
318.2369	-0.7460	SLW 1231	0.81	0.45	0.85	0.45	1	1
318.4494	74.1492	CBL 91	0.91	0.44	1.24	0.60	2	3
319.6920	21.8327	LDS 4878	1.30	0.74	1.28	0.72	4	4
320.2728	53.6226	NEW	0.82	0.52	1.03	0.69	2	3
320.5836	51.5355	NEW	0.48	0.35	0.55	0.61	0	1
321.0934	-10.5503	NEW	1.45	0.76	1.53	0.80	4	5
321.3466	52.5830	NEW	0.98	0.74	0.95	0.73	3	3
321.4797	52.2311	NEW	1.20	0.69	1.12	0.97	3	4
321.5872	7.1116	NEW	0.48	0.28	0.49	0.31	0	0
321.7870	51.8578	NEW	0.68	0.44	1.04	0.74	1	3
322.0926	19.3974	NEW	0.95	0.45	1.17	0.55	2	3
323.2605	17.3657	NEW	0.59	0.31	0.72	0.34	0	1
323.2859	-2.2200	NEW	1.34	0.70	1.42	0.73	4	4
323.5443	50.4402	NEW	0.66	0.30	0.76	0.37	0	1
324.9261	14.3850	LDS 4901	1.59	0.90	1.83	1.05	5	6
325.2194	25.5337	AZC 113	0.68	0.36	1.09	0.57	1	3
325.3350	23.9111	NEW	0.92	0.50	2.27	1.30	2	8
325.4102	20.9826	UC 4531	0.67	0.38	0.69	0.38	1	1
325.7705	24.2164	NEW	1.26	0.70	2.20	1.17	4	7
325.7925	13.8314	CBL 534	1.05	0.65	1.25	0.67	3	3
326.2730	0.3672	SLW 1252	1.26	0.66	1.52	0.77	3	4
328.0672	23.7417	NEW	1.55	0.80	1.32	0.91	5	5
328.6062	7.6378	NEW	1.26	0.70	1.39	0.80	4	4
329.1905	-4.4500	NEW	0.53	0.45	1.32	0.68	1	4
329.4003	-3.4697	LDS 4926	0.56	0.34	0.90	0.50	0	2
330.3202	-2.3535	NEW	0.46	0.28	0.57	0.34	0	0
331.2027	22.4412	CBL 538	1.30	0.72	1.36	0.72	4	4
331.2363	-9.6061	NEW	1.58	0.81	1.55	0.78	5	5
331.3875	25.3995	FMR 168	1.27	0.72	1.20	0.90	4	4
331.6505	6.8764	SLW 1261	1.16	0.62	1.70	0.90	3	5
331.8189	8.7040	NEW	0.85	0.50	1.35	0.79	2	4
332.1345	2.1601	LDS 4945	1.95	0.45	1.33	0.71	4	4
333.3313	25.0324	NEW	0.50	0.34	0.99	0.59	0	2
333.9568	0.9589	LDS 4952	0.72	0.41	0.82	0.49	1	2
334.1306	18.7533	NEW	1.03	0.54	1.60	0.88	2	5
335.8782	31.9892	LDS 4964	0.73	0.40	0.98	2.52	1	5
336.0963	-1.6424	GIC 180	0.86	0.44	0.90	0.41	1	1
336.8214	18.0835	NEW	0.88	0.47	1.48	0.78	2	4
336.9505	-4.0455	NEW	1.50	0.81	1.59	0.86	5	5
337.4019	-7.2731	NEW	1.33	0.76	1.81	1.04	4	6
337.7115	21.0546	NEW	1.46	0.76	1.48	0.73	4	4
337.9365	13.3233	CBL 541	0.63	0.39	1.05	0.59	1	3
338.3175	-7.9104	SLW 1278	1.18	0.69	1.31	0.78	3	4
338.9853	24.4336	NEW	1.22	0.71	1.33	0.82	4	4
339.0294	4.0376	NEW	1.25	0.71	1.40	0.80	4	4
339.3326	22.4123	UC 276	0.75	0.42	0.89	2.37	1	5
339.7480	11.5732	NEW	0.93	0.54	1.14	0.63	2	3
339.8554	3.6573	NEW	1.28	0.70	1.65	0.89	4	5
340.0931	10.7247	NEW	1.08	0.61	1.13	0.62	3	3

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	NAME	PRIMARY		SECONDARY		TYPE M+	TYPE M+
			(r-i)	(i-z)	(r-i)	(i-z)		
340.1422	4.8130	UC 4788	0.96	0.45	1.14	0.54	2	3
342.3576	5.2832	LDS 5002	1.32	0.66	1.80	0.92	4	6
342.8887	13.5764	NEW	1.21	0.66	1.34	0.73	3	4
343.2650	27.4462	LDS 5012	1.60	0.85	1.71	0.92	5	5
343.3717	23.5880	LDS 5014	0.55	1.09	1.53	0.85	3	5
344.2093	18.8216	NEW	0.78	0.42	0.87	0.47	1	2
344.2563	19.7471	LDS 5024	0.92	0.49	1.48	0.77	2	4
344.7357	20.2218	LDS 5033	1.10	0.63	1.25	0.71	3	4
345.0863	58.6101	NEW	0.56	0.43	0.87	0.70	1	3
345.1376	10.2863	NEW	1.71	0.93	1.74	0.92	5	5
346.1311	-19.3387	UC 4874	0.84	0.40	0.93	0.45	1	2
347.1577	1.4628	LDS 6008	1.33	0.73	1.32	0.74	4	4
347.7866	57.8106	NEW	0.66	0.50	0.83	0.67	1	2
347.9436	58.2237	NEW	0.46	0.34	0.74	0.59	0	2
348.8313	-6.8810	NEW	1.12	0.60	1.53	0.88	3	5
349.3903	57.4171	NEW	0.58	0.41	0.65	0.41	1	1
349.5095	5.3496	NEW	0.73	0.43	1.06	0.56	1	3
349.5244	-7.3409	LDS 2978	1.43	0.77	1.56	0.84	4	5
349.8584	15.6379	CBL 547	1.02	0.53	1.19	0.63	2	3
349.9249	53.1805	NEW	0.52	0.34	0.51	0.36	0	0
349.9718	-1.0904	CBL 548	1.13	0.60	1.54	0.82	3	5
350.4113	29.7427	LDS 5077	1.20	0.62	2.05	3.34	3	5
350.7054	23.3744	AZC 129	1.49	0.79	1.55	0.85	4	5
350.9869	-7.8473	LDS 2986	0.73	0.46	1.32	0.76	1	4
351.0937	35.0785	NEW	0.48	0.28	1.04	0.52	0	2
351.3788	3.4928	NEW	1.40	0.69	1.55	0.84	4	5
352.1281	-3.6990	NEW	0.71	0.40	1.09	0.52	1	2
352.4656	31.6811	NEW	1.40	0.81	1.57	0.77	4	5
352.7752	8.7004	GIC 194	1.11	0.58	2.24	0.71	3	6
353.0244	15.2238	NEW	0.76	0.35	1.38	0.67	1	4
353.2963	22.1927	UC 4981	0.79	0.40	1.12	0.55	1	3
353.3449	3.7616	NEW	1.26	0.64	1.75	0.91	3	5
353.4344	33.2785	LDS 5102	1.42	0.80	1.41	0.79	4	4
354.1972	25.4950	NEW	1.98	1.04	2.41	1.27	6	8
354.2788	-1.4730	NEW	2.26	0.31	1.56	0.96	4	5
354.3734	6.3137	SLW 1329	0.87	0.40	0.95	0.43	1	2
354.5753	61.7184	NEW	1.00	0.53	0.91	0.51	2	2
354.6033	69.1896	NEW	0.66	0.58	1.20	1.02	2	5
354.7499	3.7143	NEW	0.67	0.46	1.46	0.80	1	4
354.9839	-1.4498	LDS 5110	0.68	0.30	1.03	0.54	0	2
355.3478	-5.4040	NEW	1.46	0.86	1.49	0.86	5	5
355.4222	1.0870	NEW	0.80	0.44	1.42	0.77	1	4
356.1779	-5.1651	LDS 6056	1.24	0.66	1.19	0.61	3	3
356.2283	28.2342	LDS 5117	1.08	0.57	1.19	0.61	3	3
356.2721	21.1019	LDS 5118	0.67	0.37	0.81	0.48	1	1
356.4222	-19.6774	NEW	0.87	0.40	1.19	0.59	1	3
356.4882	12.3709	NEW	0.95	0.49	1.21	0.66	2	3
357.4130	10.4626	NEW	0.72	0.41	0.88	0.48	1	2
358.2733	7.4509	NEW	0.74	0.43	0.82	0.50	1	2
358.2780	-8.4969	LDS 3003	1.45	0.73	2.01	1.03	4	6

**Identification and Spectral Classification of Red Dwarf Common Proper Motion Binary Stars**

PRIMARY RA	PRIMARY DEC	NAME	PRIMARY		SECONDARY		TYPE M+	TYPE M+
			(r-i)	(i-z)	(r-i)	(i-z)		
358.4323	8.4169	NEW	1.84	0.29	0.97	0.53	3	2
358.6469	24.4626	CBL 550	1.13	0.60	1.17	0.62	3	3
358.8996	15.0600	NEW	1.57	0.87	1.30	0.77	5	4
359.1769	8.4959	NEW	0.94	0.52	1.31	0.71	2	4
359.3094	29.9884	AZC 132	1.16	0.60	1.49	0.81	3	5
359.5415	30.9672	LDS 5144	1.16	0.62	1.38	0.74	3	4
359.7226	1.8124	UC 300	0.59	0.34	0.80	0.44	0	1
359.8908	-10.6220	LDS 5150	1.09	0.55	1.58	0.81	3	5



# Yankee Tank Creek Observatory Report No. 1: Forty-One Measures from 2012

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**Abstract:** This report contains 41 measures of mostly STF pairs taken in 2012 and comprises those pairs not reported in other papers. All measures were taken with a 0.2M Dall-Kirkham and a DMK21 video camera working at F22.5. Both stacking and pixel correlation techniques were used to obtain measures using REDUC.

## Introduction

Herein I report a number of measures taken during 2012 and not incorporated in Wiley (2013) or Wiley (in review). Most of these pairs were picked because they are of possible astrophysical interest, displaying movement in theta and rho and having relative high proper motions. A few of the measures are check measures of rectilinear pairs based on other calibration pairs used to establish camera angle and plate scale.

## Methods

All measures were taken with a 0.2 meter Dall-Kirkham telescope with a native focal ratio of  $f/22.5$ . Images were acquired with an Image Source DMK21-618. Integration times varied between 1 second/frame and 33 milliseconds/frame while the number of frames varied between 200 and 3000, depending on integration time. The video sequences were converted to bitmap images via VirtualDub and dark-frame subtraction was used to calibrate each frame in REDUC (Losse, 2013). REDUC was used for all reductions. For each night camera angle and plate scale were determined by visualizing calibration pairs from the Catalogue of Rectilinear Elements (Hartkopf and Mason, 2011) and camera angle was checked by capturing star trails. Two kinds of data reduction were used within REDUC. Images from relatively wide pairs were grouped into four subsets. For each set the 10-25% of best images were

aligned and stacked. The resulting image was measured with the normal (non-interferometric) functions of REDUC. Relatively close pairs were analyzed by grouping the video into four subsets 500-1000 images and analyzed using the interferometric algorithm in REDUC. "Relatively wide" is a function of seeing; on nights of good to excellent seeing pairs as close as 2.5" may be analyzed using non-interferometric methods, while on nights of average seeing this may not be possible and interferometric techniques are used. These techniques follow Wiley (2013, in press). For pairs with rectilinear (Hartkopf and Mason, 2011) or orbital (Hartkopf et al. 2001-2013) solutions an O-C value is computed using either formulae in the Rectilinear Catalog or an updated version of the Workman spreadsheet (Workman, 2013).

## Results

Measures and their errors are shown in Table 1. For pairs having either orbital or rectilinear solutions an O-C value is reported with an abbreviated reference which is linked to the full reference below.

## Acknowledgements

This research has made use of the Washington Double Star Catalog, the Catalog of Rectilinear Elements, and the Sixth Catalog of Orbits of Visual Binary Stars, all maintained at the U.S. Naval Observatory as well as the Brian Workman Star Calculator.

(Continued on page 98)

## Yankee Tank Creek Observatory Report No. 1: Forty-One Measures from 2012

**Table 1. Measures reported.** Abbreviations: WDS (WDS catalog), Disc (discover code), epoch (epoch of observation), PA (position angle in degrees) Sep (separation in arcseconds), N (nights-number of images measured, e.g., 1-4 = one night and four images measures for error), errPA (error among N images in degrees), errSep (error among N images in arcseconds), method (reduction method; C is ccd reduction of N images by stacking subimages, I is autocorrelation of all images), O-C (observed vs. computed values), Ref (abbreviated reference linked to full reference in References).

WDS	Disc	epoch	PA	Sep	N	errPA	errSep	method	O-C	Ref
00063+5826	STF3062	2012.7894	352.6	1.50	3	1.15	0.004	I	+0°57/+0"10	Sod 1999
00116-0305	STF 8	2012.889	291.8	7.99	4	0.18	0.067	C	*	
00272+4959	STF 30AB	2012.9192	314.6	13.39	4	0.17	0.04	C	+0°40/-0"08	Hrt2011c
00324+1539	STF 37	2012.889	246.7	5.84	4	0.93	0.035	C	*	
00384+4059	STF 44	2012.864	273.9	12.72	3	0.06	0.013	C	+0°09/+0"10	Hrt2011c
00499+2743	STF 61	2012.889	115.2	4.29	4	0.24	0.016	C	*	
00503+3548	STF 62	2012.889	303.0	11.81	4	0.11	0.035	C	*	
00551+1333	STF 75	2012.889	273.0	5.23	4	0.27	0.017	C	*	
01001+4443	STF 79	2012.8575	193.9	7.86	5	0.26	0.016	C	*	
01001+4443	STF 79	2012.864	193.9	7.82	4	0.03	0.008	C	*	
01072-0144	STF 91	2012.9192	314.2	4.30	4	0.19	0.026	C	*	
01105-0458	STF 95	2012.9192	310.1	13.95	4	0.12	0.03	C	*	
01137+0735	STF 100A-BC	2012.889	63.2	22.80	4	0.01	0.018	C	*	
01175+2105	STF 107	2012.889	68.2	21.13	4	0.03	0.027	C	*	
01178+4901	STF 102AB-C	2012.8575	223.8	10.08	5	0.25	0.045	C	*	
01178-1220	STF 110	2012.9192	352.8	7.54	4	0.12	0.032	C	*	
01180-0420	STF 111	2012.9192	328.7	20.78	4	0.11	0.032	C	*	
01390+4104	STF 140AB	2012.864	173.9	3.43	2	0.01	0.001	I	*	
01401+3858	STF 141	2012.889	303.9	1.68	4	0.56	0.011	C	*	
01443+0929	STF 155AB	2012.889	324.6	4.95	4	0.22	0.019	I	*	
01479-0320	STF 166	2012.9192	0.2	7.78	4	0.19	0.006	C	*	
01485+6027	STF 156	2012.9192	100.9	5.87	4	0.11	0.03	C	*	
01510+2107	STF 175AB	2012.889	359.4	28.01	4	0.07	0.016	C	+0°20/+0"10	Hrt2011c
01510+2107	STF 175AB	2012.9192	359.2	27.92	4	0.03	Jan-00	C	+0°03/+0"01	Hrt2011c
01535+1918	STF 180AB	2012.864	359.9	7.45	5	0.13	0.062	I	*	
02016+2405	STF 200	2012.864	123.4	8.11	4	0.15	0.019	C	*	
02031-0725	STF 209	2012.9192	135.9	39.80	4	0.04	0.025	C	*	
02370+2439	STFA 5	2012.864	274.7	37.91	4	0.08	0.019	C	*	
02390+1452	STF 287	2012.864	73.1	6.78	4	0.1	0.056	C	*	
02563+7253	STF 312AB	2012.9192	45.2	1.79	4	0.85	0.013	I	0°32/0"02	Cve 2006e
02581+6912	STF 317	2012.9192	84.0	4.07	3	0.53	0.011	C	*	
03242+6728	STF 374	2012.9192	296.6	11.19	4	0.08	0.023	C	*	
03242+6728	STF 389AB	2012.9192	71.1	2.67	4	0.26	0.034	I	*	
04105+6009	STF 490	2012.9192	58.5	4.63	4	0.24	0.041	C	*	
18301+0404	STF2822AB	2012.7906	315.9	1.76	4	0.23	0.032	I	*	
18443+3940	STF2382AB	2012.7901	345.1	2.35	4	0.39	0.02	I	-1°69/+0"05	
19418+5032	STFA 46AB	2012.7894	132.8	39.65	5	0.05	0.033	C	-0°48/-0"07	Mrc 1999
20035+3601	STF2624AB	2012.7906	172.0	1.91	4	0.45	0.031	C	*	
23595+3343	STF3050AB	2012.7894	337.8	2.32	4	0.52	0.014	I	-0°33/0"01	Hrt 2011a
23595+3343	STF3050AB	2012.8575	338.3	2.33	5	0.12	0.038	I	-0°15/0"01	Hrt 2011a

**Yankee Tank Creek Observatory Reports No. 1: Forty-One Measures from 2012**

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*Ed Wiley recently retired from his professorial position in ecology and evolutionary biology at the University of Kansas and still maintains his research program in the evolution of fishes as part of the Euteleost Tree of Life initiative (<http://www.fishtree.org/>).*

# Three Neglected Double Stars

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**Abstract:** Three Neglected Double Star systems were imaged using a relatively small, 4.25 inch telescope and stock DSLR camera for the purpose of identification and measurement. Two were not found at the locations provided in the Washington Double Star (WDS) Catalog. Their positions may have been misplaced or these doubles were superseded by other WDS Catalog entries. A faint “C” component was found near the third neglected double.

## Introduction

Three Neglected Doubles Stars were selected for identification and measurement.

Only one was a good match for the double star listed in the Washington Double Star (WDS) neglected double star category.

Two did not match the doubles previously observed during the late 1800’s at the locations listed. However, the doubles found were well matched with other doubles stars already identified within the WDS catalog. It appears these two doubles, last observed during the late 1800’s, have been either listed at the wrong coordinates or were rediscovered at the same location listed and assigned to a different Discoverer.

## Observing List

The WDS neglected double star list was sorted, first by “last” date measured. All doubles that had been measured since 1900 were deleted. The reduced list was sorted again by separation ( $\rho$ ). All doubles with a listed  $\rho$  of less than 4 arc seconds were deleted.

Deep Sky Survey (DSS) images were examined at each “short listed” location using Skytools. Approximately 65% of the “short listed” doubles had stars at the listed locations in the DDS images. Three “positive” DSS finds were selected for imaging based on their position in the sky during the imaging session.

## Equipment and Software

### *XS Canon DSLR Camera*

A “stock” un-altered XS Canon DSLR was used to image the three double stars selected. The camera was controlled using Backyard EOS and a laptop. Each pair was imaged ten times. Each exposure was for two minutes and was captured at ISO 1600. Images were stacked with ten dark frames recorded the same night at the same camera setting to eliminated “hot” pixels. Imaging stacking was done using Deepskystacker software.

In addition, a “drift” image was recorded for 30 seconds with the equatorial mount stopped and not tracking. This produced star trails in the image that were used to establish the image angle for the camera, telescope and mount configuration.

### *REDUC*

Both the stacked and “drift” images were converted into a Bitmap file format. REDUC was used to measure each star’s Position Angle (THETA) and Separation (RHO) using these Bitmap files.

### *uniMAP*

uniMAP was used to “plate solve” each of the three imaged star fields to confirm that the telescope was pointed at the correct location during each imaging session. An example of the plate solving performed by uniMap is provided in Figure 1.

### Three Neglected Double Stars

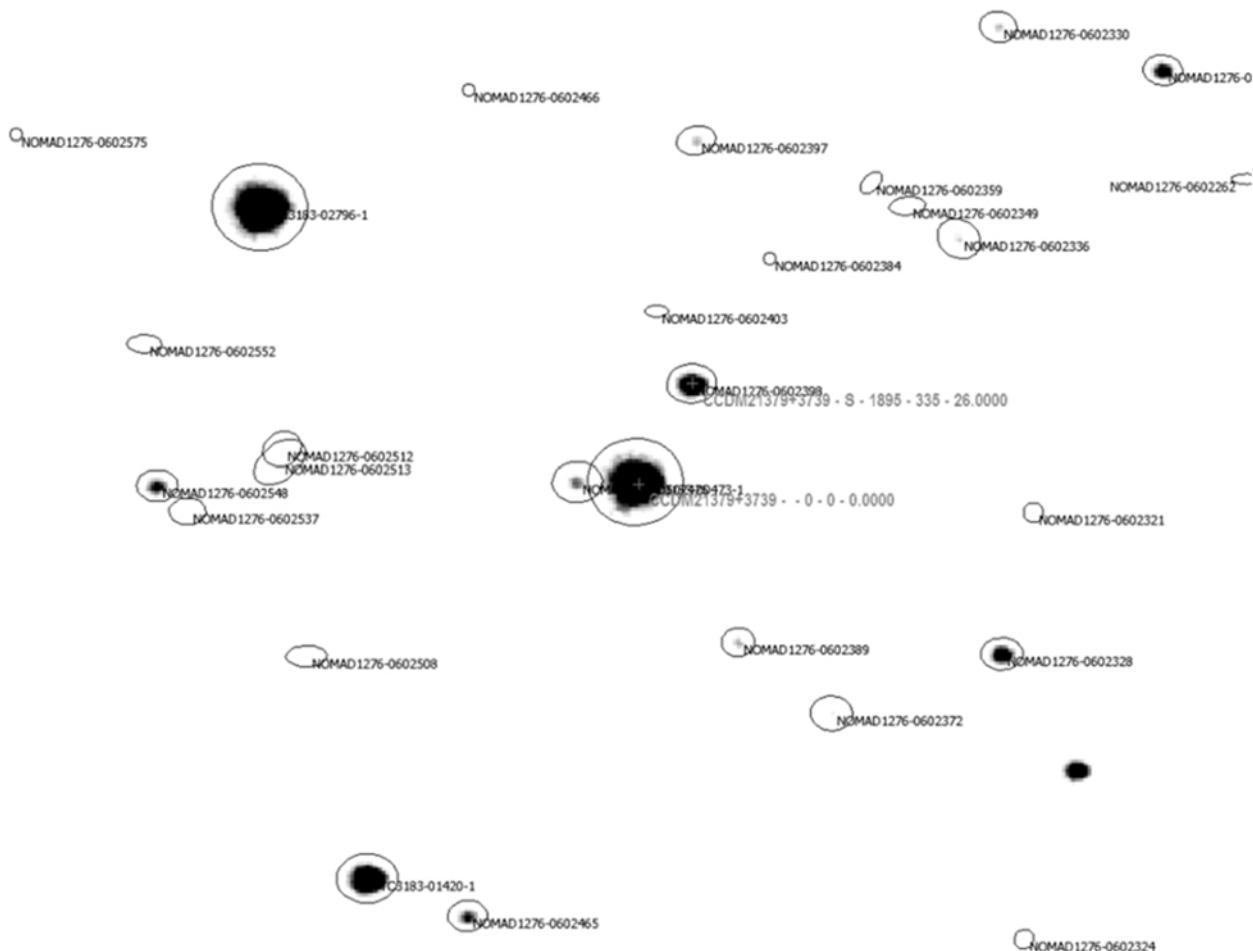


Figure 1. Example of plate solving - inverted black on white screen shot.

#### 4.25" f/28 Schießspiegler

A relatively small homemade telescope was used, a 4.25" f/28 Schießspiegler. This telescope was mounted atop an Orion Sirius German Equatorial Mount (GEM) that was controlled by a laptop using Skytools and ASCOM with an EQMOD software interface.

#### Guide Scope

A small 50mm guide telescope and an Imaging Source camera were used to guide the mount with PHD software.

#### Findings and Final Data Records

##### *Lost or Superseded Neglected Double Stars*

As mentioned above, two neglected double stars, 20066+3302 SEI879 and 20296+4041 STN 50, were not found at their listed locations.

##### **20066+3302 SEI 879**

WDS 20065+3302 GYL 23 was found at the loca-

tion listed for 20066+3302 SEI879 as shown in Figure 2. SEI879 must have been misplaced or was superseded by GYL 23.

##### **20296+4041 STN 50**

WDS 20299+4022 HJ 1525 was found at the location listed for 20296+4041 STN 50 as shown in Figure 3. STN 50 must have been misplaced or was superseded by HJ 1525.

##### **21378+3739 SEI 1527**

Even though the Neglected Double Star list shows SEI 1527 was last measured in 1895, the main WDS catalog shows it was re-measured 2007. Our measurements are consistent with the 2007 measurements as shown in Figure 4.

As seen in Figure 4, the minor "B" component of this multiple star system is clearly not within 0.5 magnitude of the major "A" component as estimated in the 1895. It is our opinion that the 2007 listed magnitude is

### Three Neglected Double Stars

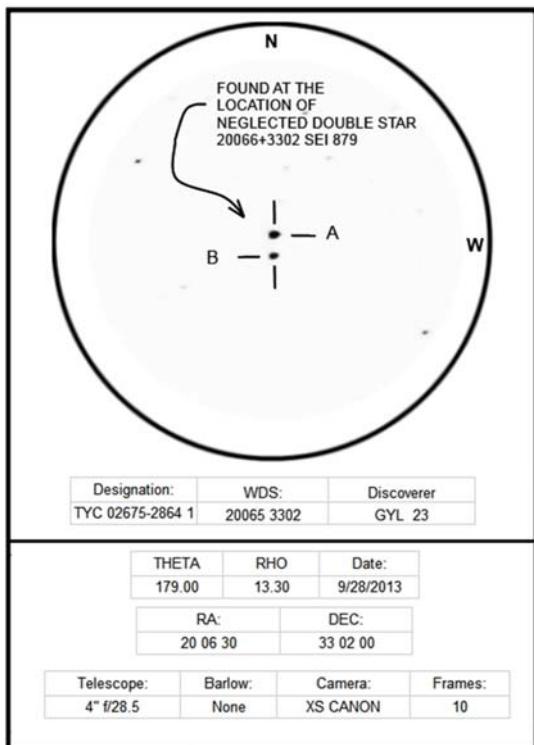


Figure 2. Measurements of WDS 20065+3302.

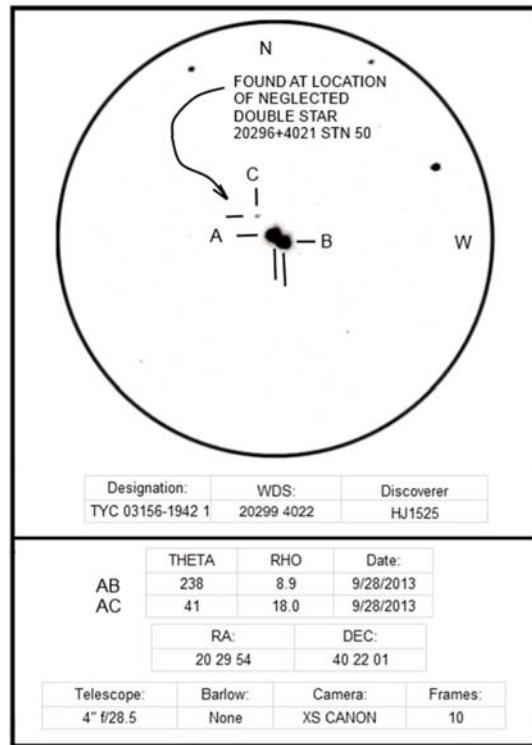


Figure 3. Measurements of WDS 20299+4022.

a better estimate of its brightness. Our measurements of THETA and RHO are very similar to those documented in 2007.

We found a third faint, "C" component, not previously listed in the WDS Catalog. This faint component is not as bright as the 12.7 magnitude "B" component measured in 2007, however, it is clearly visible in the image we captured. The plate solving software labeled this faint star NOMAD 1276060246. The NOMAD data for this star lists it as 13.8 magnitude. It has been labeled "C" in Figure 4. Component "C" THETA and RHO measurements are also provided in Figure 4.

#### Tabular Summary

Table 1 (following page) provides a summary of the measurements made related to the three (3) Neglected Doubles discussed above.

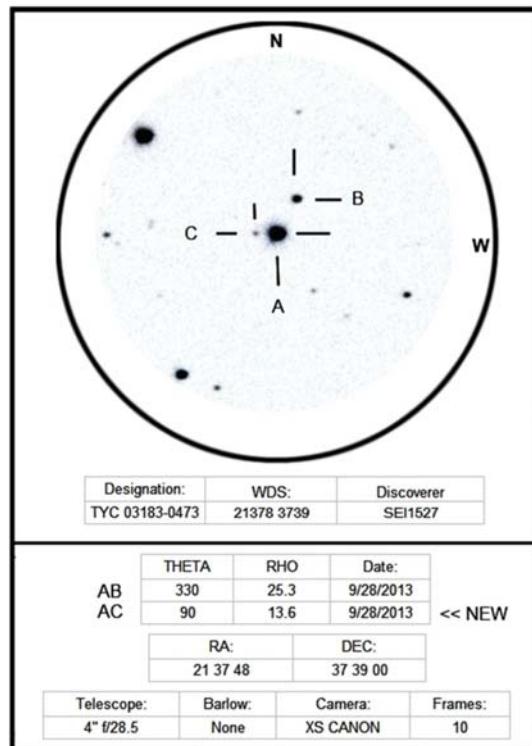


Figure 4. Measurements of WDS 21378+3739.

**Three Neglected Double Stars***Table 1 - Summary of Three (3) Neglected Double Stars Observations*

RA+DEC	Discoverer	THETA	RHO	Date	RA	DEC	N	Remarks
20065+3302	GYL 23	179	13.3	2013.741	20 06 30	33 02 00	1	NOT SEI879
20299+4022	HJ1525AB	238	8.9	2013.741	20 29 54	40 22 01	1	NOT STN 50
20299+4022	HJ1525AC	41	18.0	2013.741	20 29 54	40 22 01	1	NOT STN 50
21378+3739	SEI1527	330	25.3	2013.741	21 37 48	37 39 00	1	AB COMPONENTS
21378+3739	<NEW>	90	13.6	2013.741	21 37 48	37 39 00	1	NEW COMPONENT



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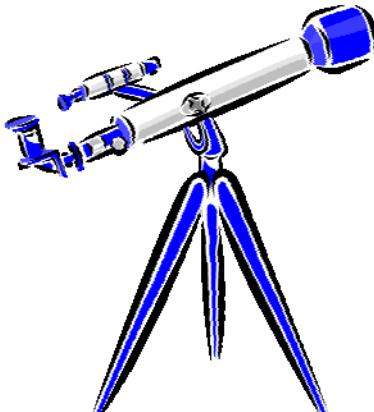
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