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Roses in the Sky

The Orion Nebula. The Trapezium is just above the center of the picture and Dawes 3 is in the lower left corner.

I really appreciate the opening to Dave Arnold's article #3 (page 54 of this issue) and can certainly agree with him.

I was observing last Thursday night and was working my way through our observing list (about 4600 objects long), and it was time for us to get another measurement of Dawes 3, a slow-moving, bright binary of about one arcsecond separation. When you have an observing list which is just a huge column of numbers you observe object after object, ticking down the list, with the hope that the observations will be useful, if not to you then to somebody, someday.

I didn't know it was coming, but had a nice "stop and smell the roses" moment, for nestled in the same field of view of my finder (actually a fabulous 8" refractor in its own right) with Dawes 3 was the Trapezium, and it was as gorgeous as ever and a tangible (or at least visible) reminder of one of the reasons we all got into astronomy in the first place.

Brian Mason

Inside this issue:

Double Star Measures for the Year 2005

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Abstract: This yearly report contains 130 measures, 7 of which are new discoveries. The instrumentation has remained unchanged over nearly three years. A review of the system characteristics is included.

Telescope

The telescope is a Schupmann medial of 9-inch clear aperture. This form of refractor is completely free of the usual secondary color of the normal Fraunhofer design. The unamplified focal length is 100-inches. A high quality Barlow lens is employed to reach a focal length of 278.82-inches which gives ~ 0.3 arc-seconds per pixel at the CCD detector. Ray trace results show the focal length stability is very high, varying only a few mm over the seasonal temperature spread. Atmospheric dispersion is easily compensated by decentering the pupil image on the Schupmann corrector.

CCD Detector

The CCD is manufactured by SBIG Astronomical Instruments and is their ST-7XE model. This detector was purchased without the usual anti-blooming gate, thus increasing both the sensitivity and dynamic range significantly. The pixel size is 9x9 microns arranged in a 765x510 array on a KAF0401E chip. The CCD camera operates with a high grade mechanical shutter. Cooling is by a single stage TE cooler

Photometric filters

Photometry is performed in the standard BVRI-bands. The filter manufacturer is Schüler Astro Imaging (now Astrodon) and the filters are made to Michael Bessel's formula as described in CCD Astronomy, Fall1995. Spectral characteristics in nanometers when used with the above CCD as follows:

Center wavelength: B= 433, V= 548, R= 639, I= 811

Half bandwidth: B=100, V=110, R=147, I=179

General Information

Data is presented in a fairly standard way; the top row gives (left to right) the discoverer designation, WDS Epoch 2000 RA & Dec, WDS magnitudes (LSO mags in brackets), LSO measured position angle in degrees, LSO measured separation in arcseconds, Decimal date and number of nights object was observed. Lastly, a notes column where a variety of data is presented as well as the note numbers which are found in the notes section after the measures & discovery notes found in the last part of the notes section. Delta m photometry results are shown as in the following example: R= 0.11 N9. This simply means that the difference in magnitude in R-band is 0.11 and 9 CCD frames were analyzed to obtain a mean value. Often included is the number of measures and time in years since the last measure: 2m105. Additional photometry data is included throughout the notes section. Astrometry values are a minimum of 12 frame means.

Double Star Measures for the Year 2005

Discoverer Des.	WDS α,δ(2000)	WDS Mags	θ (deg)	ρ(arcsec)	Date	n	Notes
BU 860	00000+3852	6.6 11.4	107.4	6.60	2005.973	1	8m72, Fixed
STI1264	00049+5933	12.1 13.8	354.8	7.19	2005.989	1	2m87, opening slightly
BU 997	00049+4540	7.47 9.63	338.1	3.96	2005.948	1	
ES 1293 AB	00052+4514	6.5 13.5	110.2	14.62	2005.951	1	2m81
BU 997 AC	00052+4514	6.71 8.83	235.9	21.36	2005.951	1	7m15
STT 547 AB	00057+4549	8.20 8.26	184.3	6.02	2005.945	1	
POP 217 AP	00057+4549	8.20 13.0	353.7	10.00	2005.945	1	2m9, Probably Optical
HJ 1001	00092+4443	8.20 10.73	77.9	15.50	2005.953	1	Practically Fixed
STF 3	00100+4623	7.51 8.86	82.4	4.98	2005.962	1	
STF 60 AB	00491+5749	3.46 7.24	318.9	12.90	2005.044	1	
BU 1 AB	00528+5638	8.58 9.33	80.1	1.13	2005.962	1	
STF 180 AB	01535+1918	3.88 3.93	0.8	7.43	2005.077	1	R=0.11N9, I=0.09 N11
STF 93 AB	02318+8916	1.97 8.2	227.7	18.23	2005.197	1	Polaris, See JDSO, this issue
STF 93 AC	02318+8916	1.97 (13.8)	96.7	38.74	2005.197	1	2m105
STF 93 AD	02318+8916	1.97 (14.3)	187.5	82.67	2005.197	1	
STF 93 BC	02318+8916	8.2 13.5	81.2	52.96	2005.197	1	
STF 93 BD	02318+8916	8.2 13.2	177.6	69.36	2005.197	1	
KUI 11 AB	03042+6142	6.62 12.5	313.1	61.0	2005.082	1	1m74, Optical ?
STF 353 AB	03075+1753	10.8 13.1	52.6	12.42	2005.079	1	3m93, R=1.65 N7
FOX 128 AC	03075+1753	10.8 13.7	16.5	30.04	2005.079	1	1m94, R=3.78 N4
STI 428	03086+6028	12.8 13.2	80.3	1.88	2005.082	1	2m83, Rapid Motion
MLB 115	03162+5810	10.53 10.81	5.9	4.90	2005.088	1	Note 1
STF 362 AB	03163+6002	8.5 8.8	141.6	7.15	2005.085	1	
STF 362 AC	03163+6002	7.9 10.5	45.5	26.69	2005.085	1	
STF 362 AD	03163+6002	7.9 11.1	285.7	28.94	2005.085	1	
STF 362 AE	03163+6002	7.9 9.9	242.1	35.17	2005.085	1	
STF 362 BE	03163+6002	8.8 9.9	253.1	37.16	2005.085	1	2m97
STI1969 AB	03165+5649	(13.7 14.0)	311.0	9.60	2005.085	1	1m94, Note 2
DAL 22 AC	03165+5649	(13.7 14.4)	222.1	32.34	2005.087	2	see Note 2
COU2164 Aa	03166+4943	10.0 11.3	------	-------	2005.088	1	Round, single image
ES 463 Aa-B	03166+4943	9.8 12.2	258.9	5.58	2005.088	1	PA ~fixed, Sep. increasing
STF 370	03166+3238	8.8 10.9	319.2	16.84	2005.090	1	5m91
BU 1039 AB	03174+0739	7.39 13.4	-------	-------	2005.101	1	not found, see BU 1039 AC

Double Star Measures for the Year 2005

Discoverer Des.	WDS α,δ(2000)	WDS Mags	θ (deg)	ρ(arcsec)	Date	n	Notes
BU 1039 AC	03174+0739	(7.35 7.70)	37.6	155.7	2005.101	1	see note 3
TOR 1	03181+2611	(10.5 13.0)	147.0	5.59	2005.096	1	1m27 Note 4
HU 545	03182+4915	9.37 10.06	81.2	3.55	2005.099	1	V=0.57 N4, I=0.33 N=8
STI1972	03184+5700	(12.44 13.01)	334.5	~~193.35~~	2005.099	1	V=0.57 N4, I=0.64 N5
PLQ 41 AB	03210+0827	8.3 12.5	310.2	42.71	2005.101	1	1m104
PLQ 41 AC	03210+0827	8.3 12.7	7.9	50.75	2005.101	1	2m85
STF 410	03350+3201	6.6 10.6	212.8	5.21	2005.118	1	closing slightly
BRT1177	03508+1418	11.2 11.5	181.3	4.19	2005.120	1	2m23, closing slightly
KUI 14	03519+3422	5.77 13.2	29.7	14.97	2005.120	1	1m47, little motion
STI2051	04312+5858	12.7 12.7	62.42	9.31	2005.134	2	White Dwarf & M4 pair
STI2055	04340+5808	12.4 12.4	330.4	4.74	2005.159	1	3m16
DAL 23	04343+5910	(12.05 13.03)	108.1	4.41	2005.128	2	discovery note 1
ES 1524	04509+4300	9.0 14.2	85.9	6.33	2005.148	1	1m89,PA incr.,opng slightly
STF 688 A-BC	05145-0812	0.3 10.4	203.8	9.42	2005.148	1	Rigel
STF 738 AB	05351+0956	3.51 5.45	43.5	4.33	2005.189	1	I=2.09 N18, Lambda Ori
STF 738 AC	05351+0956	3.51 10.7	183.6	28.45	2005.189	1	
STF 738 AD	05351+0956	3.51 11.2	271.3	78.10	2005.189	1	
STT 134	06093+2426	(7.38 8.94)	189.4	31.06	2005.170	1	V=1.56 N9, I=2.52 N6
STF 872 AB	06156+3609	6.89 7.38	216.3	11.37	2005.159	1	V=0.60 N8, I=0.66 N8
STF 943 AB	06378+2311	(9.04 9.43)	135.4	30.37	2005.170	1	V=0.39 N6, I=0.05 N5
STF1066	07201+2159	3.55 8.18	226.8	5.66	2005.189	1	Delta Gem
STF1083	07256+2030	7.32 8.13	45.3	6.69	2005.236	1	
STF1110 AB	07346+3153	1.93 2.97	61.1	4.25	2005.227	1	Castor
STF1196 AC	08122+1739	5.31 5.85	71.3	6.34	2005.263	1	Zeta Cancri
KU 32	08413+1916	8.06 10.24	165.8	2.19	2005.274	1	
STF1273 AB-C	08468+0625	3.49 6.66	300.2	3.01	2005.244	1	Epsilon Hydrae
STF1273AB-D	08468+0625	3.49 12.5	200.0	18.11	2005.293	1	
HDS1318	09050+2250	7.46 10.56	------	------	2005.299	1	secondary not de-tected
STF1311 AB	09074+2259	6.92 7.13	198.9	7.72	2005.296	1	I=0.33 N8
HO 644 AC	09074+2259	6.3 12.6	116.8	27.87	2005.299	1	cpm, see note 5
STF1321 AB	09144+5241	7.79 7.88	94.5	17.12	2005.315	1	
POU3077	10170+2326	12.4 12.9	276.6	4.76	2005.340	1	2m95, little motion
STT 523	10172+2306	5.81 11.4	298.9	7.73	2005.337	1	I=4.62 N10

Double Star Measures for the Year 2005

Discoverer Des.	WDS α,δ(2000)	WDS Mags	θ (deg)	ρ(arcsec)	Date	n	Notes
STF1421	10181+2731	8.19 9.12	330.9	4.50	2005.318	1	V=1.01 N12, I= 1.21 N11
STF1424 AB	10200+1950	2.37 3.64	126.0	4.57	2005.362	1	Gamma Leo
LDS1251	10374+3133	11.8 17.2	47.5	32.03	2005.356	1	cpm pair, WD candidate
STF1458	10395+3142	9.39 9.39	216.7	18.13	2005.353	1	very slow binary
STF1459	10402+3824	8.34 8.85	152.7	5.39	2005.359	1	
STF1524	11185+3306	3.48 10.1	148.6	7.35	2005.362	1	
LDS6246 AB	11378+4150	10.3 16.0	340.1	28.53	2005.367	1	1m45, PA decr, sep incr
DAL 24 AC	11378+4150	10.3 (17.0)	174.7	5.85	2005.367	1	discovery measure
STT 237	11390+4109	8.11 9.32	247.1	1.92	2005.367	1	
STF1622	12161+4040	5.86 8.71	260.2	11.54	2005.399	2	2 CVn
STF3127 Aa-B	17150+2450	3.14 8.3	283.3	11.77	2005.627	1	Delta Her, B Optical
STF2186	17358+0100	7.55 7.72	78.6	2.83	2005.641	1	
STF2213	17449+3108	7.69 8.57	327.8	4.73	2005.644	2	V=0.82 N8
DAL 25	17556+2250	(9.6 11.1)	153.7	44.23	2005.655	1	discovery note 2
STF2271 AB	18003+5251	8.17 9.24	268.0	3.30	2005.674	1	V=0.77 N6, I=0.64 N6
STF2280 Aa-B	18078+2606	5.79 5.83	183.2	14.21	2005.679	1	V=-0.05 N8, I=0.03 N8, var
STF2323 AB	18239+5848	4.98 7.98	348.7	3.76	2005.693	1	39 Dra
HO 432 AB	18240+3844	6.4 12.9	285.5	17.49	2005.696	1	5m71, PA decr. difficult pair
STF2349	18366+3328	5.4 9.4	204.6	7.22	2005.699	1	
H 4 59	18367+3841	10.0 11.1	299.0	29.86	2005.627	1	6m75, PA smoothly decr.
H 5 39 AB	18369+3846	0.03 9.5	182.3	79.20	2005.833	1	Vega
HJ 1337	18409+3132	(8.62 11.51)	153.5	9.29	2005.679	1	V=2.89 N 8, I=1.86 N14
STF2398 AB	18428+5933	8.94 9.69	175.5	12.24	2005.627	1	11.6 ly, M4 M5 Binary
STF 38 AD	18448+3736	4.34 5.73	149.9	43.58	2005.718	1	
STF2375 Aa-Bb	18455+0530	5.82 5.82	118.9	2.44	2005.731	1	
ES 2028 BC	18545+3654	11.2 11.6	135.5	1.92	2005.715	1	
STF2434 A-BC	19027-0043	8.36 8.80	91.7	26.82	2005.742	1	
STF2446 AB	19058+0633	6.97 8.88	153.1	9.45	2005.756	1	
STF2455	19069+2210	7.24 9.38	28.5	8.99	2005.764	1	
STF2457	19071+2235	7.43 9.60	200.6	10.13	2005.764	1	
STF2486 AB	19121+4951	6.54 6.67	205.8	7.31	2005.723	1	V=0.16 N8, I=0.18 N8
BUP 188	19198+6423	6.25 9.8	179.9	115.2	2005.731	1	
STI 888	19210+6405	11.1 11.4	172.7	3.80	2005.742	1	3m22, PA decr, sep incr

Double Star Measures for the Year 2005

Discoverer Des.	WDS α,δ(2000)	WDS Mags	θ (deg)	ρ(arcsec)	Date	n	Notes
STI2426	19210+5631	(13.1 13.3)	160.2	10.83	2005.753	1	see note 6
STI 890	19213+6412	10.1 10.4	146.6	4.85	2005.731	1	sep & PA decreasing
STI 887	19213+6227	11.4 11.7	90.3	7.91	2005.742	1	1m102, little motion
DAL 26	19260+6353	(10.7810.95	301.7	18.30	2005.731	1	discovery note 3
DAL 20 AB	19346+5039	11.38 11.45	50.2	28.74	2005.803	1	
ES 793 AB	19351+5046	10.9 11.2	245.3	44.84	2005.803	1	
ES 793 BC	19351+5046	11.2 13.6	282.7	4.04	2005.805	1	1m96, large PA incr, closing
ES 793 Aa	19351+5046	10.3 14.8	91.1	14.98	2005.805	1	1m96, slight PA incr
DAL 19 AB	19352+5048	11.32 13.4	191.1	2.80	2005.803	1	difficult CCD pair
DAL 19 AC	19352+5048	11.32 12.9	39.4	9.41	2005.803	1	opening ?
STF 46	19418+5032	6.00 6.23	133.2	39.51	2005.756	1	photometric calibration pair
DAL 27 AD	19508+0852	0.76 11.7	95.6	32.12	2005.838	2	Altair, discovery note 4
HJ 2921	20027-0036	(8.36 11.84)	341.1	21.72	2005.762	1	3m94, PA incr, Sep incr
STF2725	20462+1554	7.09 7.90	11.2	6.07	2005.759	1	
STF2727	20467+1607	4.27 5.15	266.4	9.12	2005.759	1	Gamma Del
BU 678 AB	21008-0821	8.20 11.26	255.5	2.67	2005.875	2	under-measured binary!
STF2758 AB	21069+3845	5.20 6.05	151.0	30.93	2005.753	1	61 Cyg
STF 11 AB	21221+1948	4.20 7.56	311.6	36.10	2005.871	1	1 Peg
STF2863 Aa-B	22038+6438	4.26 6.34	275.0	7.94	2005.888	1	
STF2909	22288-0001	4.36 4.57	175.4	1.86	2005.937	1	Zeta Aqr
STF2922 Aa-B	22359+3938	5.73 6.60	185.7	22.26	2005.882	1	8 Lac
A 1469 Aa-C	22359+3938	5.73 10.5	168.3	48.33	2005.882	1	
STF2922 BC	22359+3938	6.45 10.3	154.5	27.86	2005.882	1	
A 1469 CD	22359+3938	10.3 9.6	116.2	42.11	2005.882	1	
A 1469 Da	22359+3938	9.6 13.3	228.0	9.65	2005.885	1	5m70, PA incr
DAL 28 Aa-G	22359+3938	5.73 13.6	193.7	78.60	2005.885	1	CCD discovery
DAL 28 Ga	22359+3938	13.6 14.0	77.0	6.51	2005.885	1	CCD discovery
STI1116	22360+6347	11.2 11.7	169.9	8.26	2005.888	1	1m96, PA incr, Sep incr
ES 2133	22360+3520	9.4 12.9	91.9	3.53	2005.896	1	1m81, PA incr, Sep decr
POU5724	22360+2523	12.5 13.5	140.5	6.33	2005.901	1	1m107, closing only
MLB 97	22361+6053	9.9 11.4	62.5	7.18	2005.901	1	3m87, little motion

Double Star Measures for the Year 2005

2005 Notes

1) MLB 115 - A delightful CCD binary, this gem's distance is listed as only 43.9 light years. The pair shows fairly fast motion which can be detected on a yearly basis with some care. Photometric work on this system proved perplexing as the components seem redder than the Hipparcos combined V-I value of 1.75 would indicate. The LSO determined Δm and colors as follows V-band = 0.20 N9, I band = 0.07 N8, V-I primary = 2.44, secondary 2.57. The pair was spot checked on the next night which confirmed these results.

2) STI 1969 AB - This pair is visually much fainter than Stein's photographic measure of 12.6 and required good dark adaption to center it up. The V-band measure reverses Stein's designation for the primary and is reflected in the LSO position angle flip. Very little (~3°) actual PA motion since discovery, however, the separation has increased about 0.40 arcseconds. The magnitudes listed in this report are LSO values. A third component (DAL 22AC) was found by CCD, thus the AB designation. Δm and colors as follows: V-band AB=0.38 N7, AC=0.66 N7, I-band AB=0.36 N7, AC=0.55 N7, V-I A=1.19, B=1.21, C=1.30.

3) BU 1039 AC- This wide pair is a distinctive sight in the 3-inch finder, the brighter component being the primary of BU 1039 AB which was the neglected double for that night. 107 years have past since the last measure, but since it showed an opening indication between 1889 and 1898 it was thought that it might be possible to image it. Every sort of exposure and filter was tried to image the 13.4 magnitude companion without success. Setting the proper motion command to 1,500 years in *Guide-8* revealed that the primary had a substantial vector length, however, and more surprising, both components of the wide pair showed the same vector length and direction. (See Figure 1) Hipparcos PM values in milliarcseconds are A=RA 169.3 , Dec -7.64 and B= RA 170.4, Dec -7.48. This carries the pair along about 4.6 arcminutes in 1,500 years in PA 92.5 degrees. If BU 1039 was not bound it should have revealed itself. A 13.4 magnitude star was easily found in the trailed-off direction , but over 1'49" away, much too far to be caused by proper motion of "A" alone. Getting back to BU 1039 AC, the Δm and colors follow: V-band =0.35 N4, I-band = 0.38 N6, V-I A=0.77, C=0.74. The listed distance to the pair is about 155 ly, so if we are observing them "broadside" the physical separation is only 0.1 light years or so, thus a fair possibility of true duplicity.

4) TOR 1 - LSO measured V magnitudes (10.51 12.96) are very close to one magnitude fainter than TOR values for both the primary and secondary. Δm and colors as follows: V-band = 2.45 N3, I-band = 2.07 N4, V-I primary = 0.84, V-I secondary = 1.22. This photometric data is a four frame average in each color. Colors hint at a physical system. Good student project. Very little motion since discovery. PA increasing ~1 degree and opening slightly.

5) HO 644 AC - This distant component of STF 1311 AB shows no significant change in position since the last measure in 1909 even thought the AB pair's proper motion is quite large (.168 mas / yr mostly in RA) and should have changed the separation about 16 arcseconds if a background star. To fully confirm the apparent physical connection to the main pair, photometry in V & I-bands was performed. Δm and color as follows: V-band = 6.39 N6, I-band = 4.87 N3, V-I for C = 2.11. The color indicates an M0 or M1 red dwarf and the Δm agrees with what one would expect for an ~M0 dwarf at the distance of the main pair (192 ± 15 ly.).

6) STI 2426 - Stein's original measure of 1917 gives a PA of 144° and a separation of 10.3". Now, 88 years later we find this neglected pair's PA has increased 16° and has widened about 0.5". This is enough motion to take the next step: a look at the colors to see if, perhaps, the pair is a binary . First off, LSO V-band measures find the pair roughly 2 magnitudes fainter than Stein's measure. This cannot be

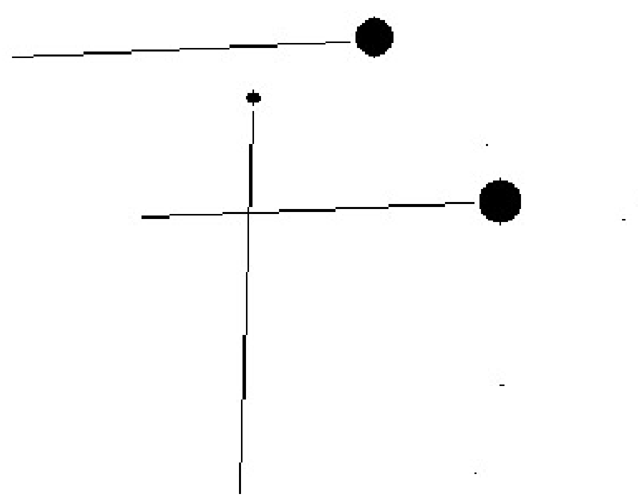

Figure 1: Guide-8 chart of BU1039 AC showing 1500 year pm.

explained by Stein's use of blue plates; as we shall see, the pair is distinctly orange. LSO listed mags are, however, in reasonable agreement with the GSC values of 13.1 13.8.

LSO Δm values as follows: V-band 0.20, R-band 0.40, I-band 0.44. LSO colors as follows: V-I primary = 0.84, secondary = 0.60. It appears that the secondary is the "bluer"; not a hopeful sign. More study of this pair may be needed to resolve the pair's nature.

Discovery Notes

1) DAL 23 - 04hr 34m 19.7142s +59deg 10' 29.680". Found while sweeping for STI 2051. A conspicuous visual pair even in nearby moonlight. The primary is GSC identifier 3744 1389 with proper motion in milliarcseconds / yr as follows: RA 26 ± 3, dec -20 ± 3. LSO magnitudes 12.05 and 13.03 . These are both, more or less, reddish stars with LSO V-I values for the primary of 0.90 and 1.69 for the secondary. Δm as follows V-band =0.98 N7, R-band =0.59 N3, I-band= 0.19 N10. It is quite possible that the secondary is a wide range variable which would explain this pair being missed in the past. Fig 2 below shows a CCD image of the pair.

2) DAL 25 - 17hr 55m 35.549s + 22deg 50' 14.007". CPM pair: Tycho-2 catalog data for proper motion (MAS/yr) of primary: RA: -54 , dec: -21, secondary: RA: -54, dec: -23, all with an uncertainty of ±1. LSO V-I colors : primary = 0.78, secondary = 1.09. Δm V-band = 1.49 N10, I-band = 1.20 N4. Another interesting student project!

3) DAL 26 - 19hr 26m 03.6001s +63deg 53' 25.573" CPM pair: Tycho-2 catalog for proper motion (MAS/yr) of primary: RA: -17, dec 31, secondary : RA: -14, dec 35, all uncertain by ± 4. LSO magnitudes listed in results. LSO V-I colors: Primary = 0.81, secondary = 0.82. Δm B-band = 0.16 N7, V-band = 0.17 N7, I-band = 0.17 N7. This is a great one for the catalog mining gurus. Bet it's a binary!

4) DAL 27 AD - A new, comparatively close, component of Altair. Discovered in the process of testing LSO's new stellar coronagraph. Altair lies at only 16.7 ly, thus attendants, even faint ones, cannot be simply dismissed as remote field stars. LSO colors weakly suggest a K5 or later object, however, the errors of measurement even leave open the possibility of some sort of white dwarf! The color and magnitude of this object puts it approximately at Altair's distance. Whether or not this is a physical attendant will be decided in short order, say 2 years, as the proper motion of Altair is very high. Perhaps next Summer a publishable measure of color will be possible. Figure 3 shows Altair, mostly hidden behind the occulting bar, with the new component to the left. The occulting bar runs from lower left to upper right leaving the orthogonal spillover. The center wavelength is 580nm and the FWHM is around 200nm. North is down and East is left.

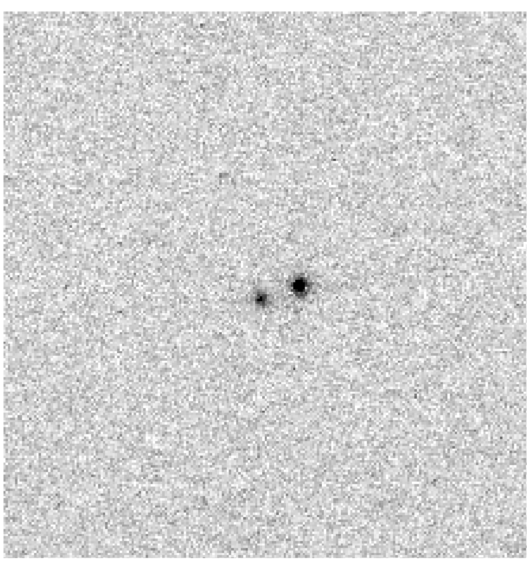

Figure 2: CCD image of DAL 23.

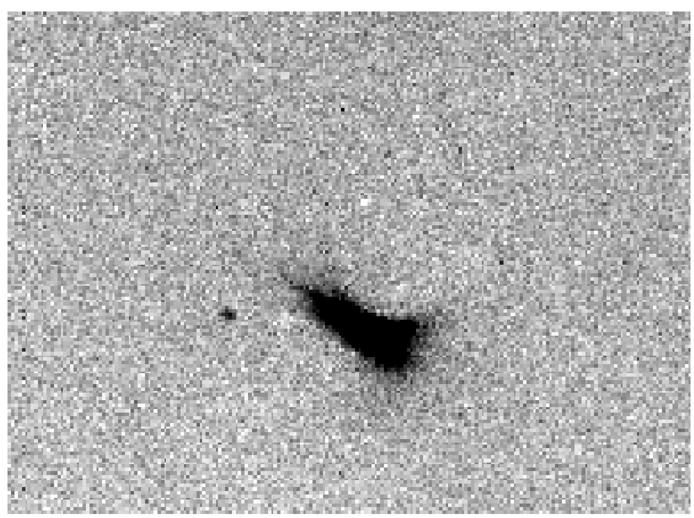

Figure 3: Altair's light about 96% occulted, showing companion. Exposure 25 seconds, 3X3 binned.

CCD Imaging of STF 93 C & D

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Abstract: Polaris (STF 93) is a bright Cepheid variable, thus most interesting to the astrophysicist . One, for instance, may ask if the birth of these milepost stars typically involve the formation of additional physical components. Close study of Polaris and its 5 attendants, one spectroscopic, perhaps one interferometric and three visual, may help in the understanding of these special object's evolution. In addition to Sir William Herschel's early discovery of the B component, Burnham, in 1884, discovered C&D, both much fainter companions of Polaris. The last observation and measurement of "C" was by Burnham in 1890 and "D" was recently (1999) identified in 2 MASS images. Described here is the technique used to recover C and solidly image both C&D in the presents of the bright primary. These images were measured (results reported elsewhere) to obtain accurate positions angles and separations of the B, C & D components. Preliminary color measurements of C&D were performed and is reported here. This work is in response to a challenge by Dr. Brian Mason of the USNO to the double star group to recover and measure the positions of these two faint components. The observing period was March13 through April 16, 2005.

Introduction

Measuring faint components in the presence of a bright primary presents an especially difficult task, even with a CCD detector. As the exposure is increased to reveal the dim attendant stars, the light scatter in the telescope, CCD saturation effects, reflections off the pixel array to the chamber widow and back, and the Airy rings themselves, all add to an image blur of the primary perhaps 40 times or more greater in diameter than a properly exposed image. When the light ratio between the primary and faint components reach about 60,000 or about 12 magnitudes, the direct detection of these are limited to separations on the order of 50 arc seconds. Special instruments are currently employed to overcome these limitations and are patterned after Lyot's white light solar coronagraph where special occultors block, not only the offending star, but also the strong diffracted light originating at the entrance pupil rim. Great care is taken to also reduce various other instrumental sources of scattered light. Currently, circumstellar disks surrounding bright nearby stars, such as Beta Pictoris, are being revealed with such instruments.

A much simpler and older method, called the focal plane masking bar, can achieve satisfactory results for less demanding work. Visual observers sometimes use a bar mask in the field stop of their eyepiece to better view faint adjacent objects. In the measurements described here, a mask was placed against the outer surface of the CCD chamber window. Because the mask was located about 12mm before focus, some annoying mask diffraction was present, but not so harsh as to prevent a satisfactory result. Placing the mask against the chip face was considered, but the risk of damage was considered too great. The 1mm wide masks were of two types. The first a totally opaque foil and the second a #29 Kodak red gelatin filter. In the second type the filter, when combined with a photometric V-band filter, greatly attenuated the primary, but left the faint components "in the clear," transmitting through the V-band alone. This optical trick allowed the measurement of PA and Separation of all components. Proceeding with example CCD images, I tell my little story.

The Images

All CCD images were obtained with an ST-7XE

CCD Imaging of STF 93 C&D

camera manufactured by Santa Barbara Instrument Group (SBIG). The camera employs a Kodak KAF0401E chip without an anti- blooming gate. The camera is used at the 278.8-inch focus of an 9-inch medial refractor. Except where noted, North is up and East is left in the following images.

Figure 1 is a short (1 sec) exposure of Polaris and its popular companion, a view familiar to us all. A photometric R-band filter was used to improve contrast. Slight saturation of the primary is evident.

Next, an attempt was made to directly detect components C&D. This image (see Figure 2), although revealing their presence, left the primary saturated,

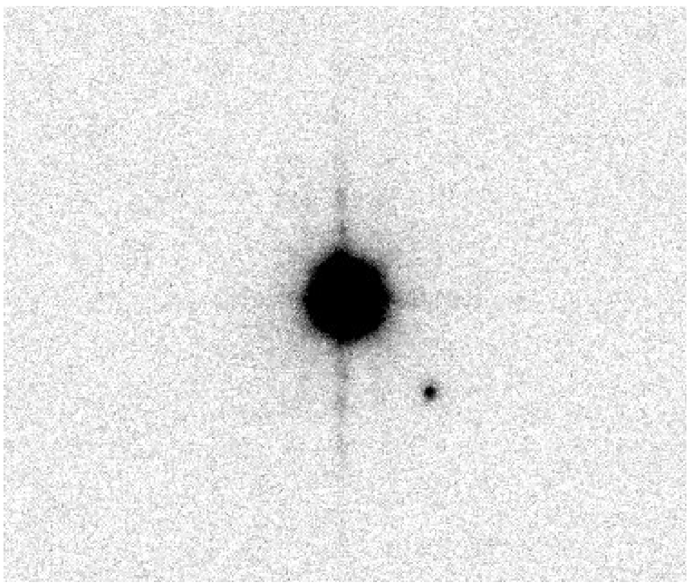

Figure 1: Polaris and its well known physical companion. Exposure: 1 second in R-band. No binning.

thus leaving no hope of determining its centroid. The signal to noise level of the faint components is also rather poor for accurate work. The scattered light surrounding the primary shows both a peculiar diffraction pattern and diffraction "spikes" typical of a 4 vane spider, yet the aperture is un-obscured. This pattern is, instead, most likely caused by CCD saturation and reflections from the CCD array itself and the chamber window. The non-telescopic origin of the bulk of this "scatter" is easily demonstrated by rotating the CCD head, where the pattern remains fixed in orientation and appearance with respect to the display.

To measure positions the color filter bar mask was employed and a typical image in this mode can be seen in Figure 3. Varying the background and level

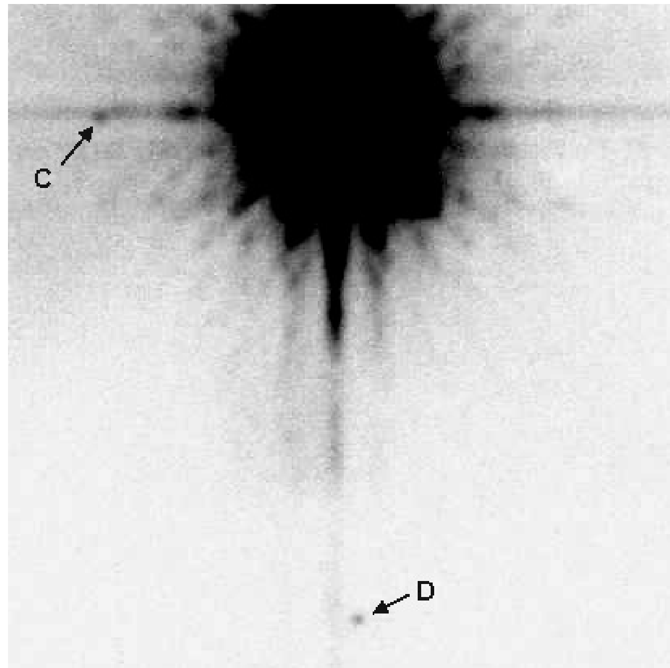

Figure 2: Two stacked 40-second exposures of Polaris in R-band. No binning.

controls allowed good initial location of the primary centroid and could be sensitively trimmed to near zero error by careful adjustment of the sample area and its location. From there the other component's PA and separation is just a few keystrokes away. Polaris trails were used to correct the PA errors introduced from working so close to the true pole. Many images were taken and measured to reduce errors.

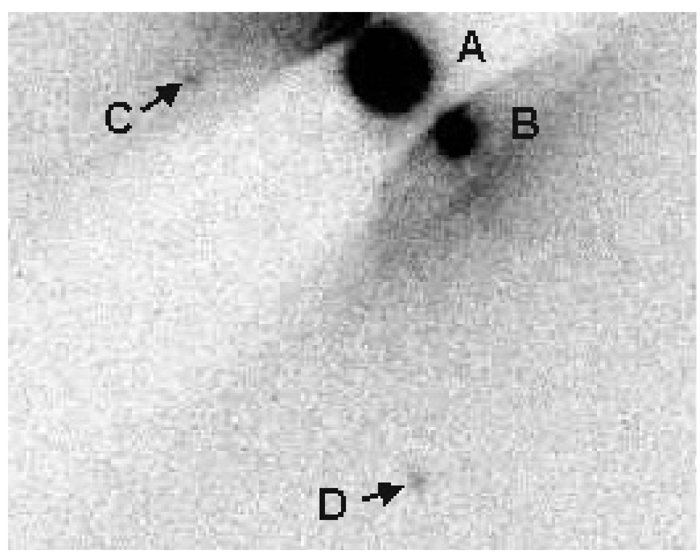

Figure 3: Polaris attenuated with red gelatin mask and V-band photometric filter. Image 2X2 Binned

CCD Imaging of STF 93 C&D

Finally, an attempt to measure the color index of C&D was made using opaque occulting bars and mini cones suspended on 0.007 wire. The occulting bar method proved best and an example unfiltered image, shown in fig 4, reveals many very faint field stars with the C&D components well exposed. The CCD head was rotated to better situate "C" so North is now upper left. Many exposures in V, R, and I-bands were made to arrive at preliminary magnitudes and color indices as follows: C component: V-band mag = ~13.80 R-I = 0.56, D component: V-band magnitude 14.3 R-I= 0.67, V-I = 1.08, Obtaining V-I values for "C" proved very difficult due to excess scatter in V-band for this closer in star.

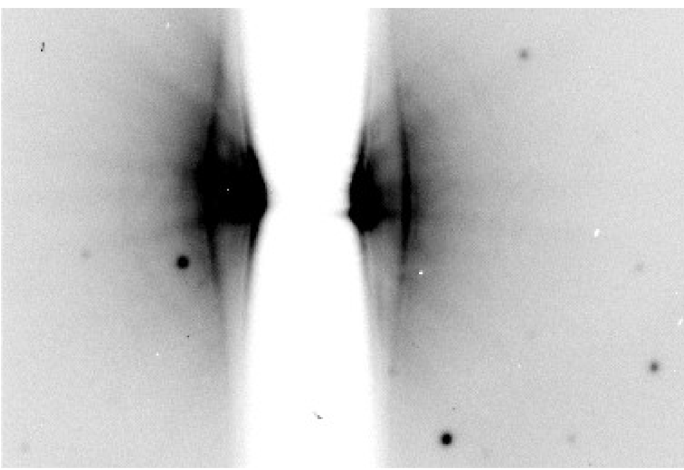

Figure 4: This image shows Polaris occulted with a foil bar. The faint components C and D are now well revealed. Exposure: 200 seconds, unfiltered.

Tentative Conclusion

The color work in R and I-bands show both components lying somewhere near a spectral class K5V or perhaps slightly redder. Polaris is a supergiant of spectral class F7 1b with an absolute magnitude of -3.64 . Assuming C and D are main sequence K5V objects, their absolute magnitude is about 7.4. Stars of these two spectral classes (F8 1b & K5V would show a magnitude difference of ~11.0 if at the same distance. Polaris is listed at magnitude 1.97 so using LSO magnitudes a Δm of 11.8 for AC and 12.3 for AD is obtained. The color / magnitude slope in the region of K5 is steep and small errors of color measurement can swing the predicted Δm considerably either way. Also the measure of the V-magnitude is noisy and uncertain, further limiting the precision. Despite these difficulties the data do weakly infer that C and D may be physical with Polaris!

Future Studies

Obviously, the occulting method needs improvement to reduce scattered light in B & V-bands. I am presently designing a prime focus occulting arrangement to make use of the coronagraphic properties of the medial instrument. This color index work on Polaris's faint outer companions is an ongoing project, and hopefully in the spring of 2006 the instrumentation will be fully up to the task. A well made stellar coronagraph could prove to be a useful tool for amateur studies of other binaries.

Jim is a retired optical research worker and presently lives in southern NH. He measures doubles from his homemade backyard observatory located at an elevation of 1,300 feet. He reminds us to note that Polaris's very close companion Ab was recently resolved by Hubble in an imaging program headed up by Dr.Nancy Evans of CfA.

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Abstract: This report contains theta/rho measurements from 95 different double star systems. The time period spans from 2004.697 to 2004.770. All measurements were obtained using a 20-cm Schmidt-Cassegrain telescope and an illuminated reticle micrometer. This report represents a portion of the work that is currently being conducted in double star astronomy at Divinus Lux Observatory in Flagstaff, Arizona.

Several weeks ago, I was privileged to experience one of those rare "number 10" nights while I was measuring double stars in the star fields of Cygnus. During this observing session, a couple of aspects of observational astronomy occurred to me that served as a reminder of some factors that most of us know, but sometimes forget.

First of all, most telescopes that are manufactured for serious work perform in an outstanding manner on those nights when the atmosphere provides nearly perfect seeing and transparency to the observer. On such nights, the telescopic field of view can be full of faint stars that appear to be "rock steady." As a consequence, some double stars that are normally too close together, or too faint to measure, are within reach of one's instrumentation. On the night that I referred to above, I was easily able to measure a pair of magnitude +10 stars that were separated by 5 arc seconds. On an average night, such a measurement can present quite a challenge when using an illuminated micrometer. Hence, on a perfect night, one can come to appreciate the fact that his or her telescope <u>does</u> contain high quality optics after all.

Secondly, when one is working in a crowded star field, such as the one that exists in Cygnus, the number of double stars that appear in a "low power" field of view can be almost overwhelming, especially when one is sky sweeping. The temptation may be to forget about the double stars that are on the measuring list for that night, and simply enjoy the sight for its own sake. Maybe that is not such a bad thing to do on occasion. When the sky is nearly perfect, one may also wish to determine what the double star measuring limits really are for one's optics, by selecting the closest and faintest double star that appears to be within range.

Perhaps the point of this discussion is simply to say that one should stop and "smell the roses" once in a while, so that one's research efforts don't get caught up in a stale routine. This is one way to guard against a loss of enthusiasm for this work, especially after a long period of time, which is something that I must also be alert to when working on an extended research project of this sort.

This article contains a listing of double star measurements that are part of a series, which have been continuously reported at Divinus Lux Observatory, since the spring of 2001. As has been done in previous articles, this one includes a continuation of measures that have been taken from the 2001.0 version of the WDS CATALOG, with published measurements that are no more recent than ten years ago. Exceptions to this time stipulation include STF 2758 AB, STF 2725, STF 60 AB, and STF 296 AB, because the theta/rho shifts for these confirmed binary stars are large enough to warrant more frequent measurements. There are also some noteworthy items that are discussed in reference to the following table.

First of all, WFC 365 has displayed a position angle increase of approximately 15.5 degrees and a separation increase of 2.2" (20%) since the last published measurements in 1906. If this double star is a common proper motion pair, which appears to be the case, these shifts might be caused by orbital motion if this system is truly binary in nature. The reason for being cautious in making this statement is because this dou-

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ble star has only had one set of measurements, from 1906, listed in the WDS Catalog

WFC 15 is another double star that has had a position angle increase, possibly because of orbital motion. Since 1957, this common proper motion pair appears to have shown an increase of almost 12 degrees. If this amount of change is real, then the rate of change has recently increased as well. This might imply that the companion star is approaching periastron. Orbital motion is the likely cause of a 2.3 degrees increase in the theta value for STF 60 AB, since 1999. This statement can be made with a greater degree of confidence because this pair is a confirmed visual binary star that has had orbital elements preliminarily determined.

One possible new double star, labeled as ARN 83, is listed in the table because this pair does not appear to have been previously cataloged. While care is usually taken to avoid submitting new double stars that don't share a common proper motion, this particular entry might not meet this constraint. The reason for making this submission is because the separation is decreasing between the components, both stars display the same spectral type, and the magnitudes are similar. Time will reveal whether the decrease in separation is caused by orbital motion or by discordant proper motions.

Also being reported in this article are measurements of double stars that have displayed theta/rho shifts because of proper motions by one or both of the components. Four such systems are HJ 927, BU 764 AB-C, STT 24 AB, and AG 239. For HJ 927, proper motion by the reference point star is responsible for a 3.4% separation increase since 1991. In the case of BU 764 AB-C, proper motion by the "C" component is the primary cause for a 2.3% separation increase since 1910. In regards to STT 24 AB, proper motion by both components has contributed to a 4.2% increase in separation since 1995. For AG239, proper motion by the companion star has brought about a 2.5 degrees decrease in the theta value since 1991.

Additional double stars showing shifts from proper motion include ENG 80 AC, BU 988 AC, and STF 2758 Aa. For ENG 80 AC, a large proper motion by the reference point star has caused a 4.2" decrease in separation since 1991. A large decrease in the position angle, amounting to 5.5 degrees since 1991, has been caused by the proper motion of the "C" component in BU 988AC. Regarding STF 2758 Aa, a large common proper motion by the "AB" components is responsible for decreases of 89 degrees in position angle and 68.5" in separation since 1921! Because the proper motion of "AB" is so large, the "C," "D," "E," and "a" components of STF 2758 are being "left behind." "AC" now shows a separation of 782".2, while the separation value for "AD" is 691".5 according to the Hipparcos/Tycho catalogs. The position angles are 219 and 251 degrees respectively. Listings for these components do not appear in the table because my micrometer cannot measure components that are so widely separated. Measurements for "AE" were previously done on August 16, 2002.

Also worthy of mention are the theta/rho shifts that have been measured in the AG 239, SEI 882 AB/ES 2690 AC, and SEI 1023 star systems. A large proper motion by the companion star, in AG 239, has caused a 2.4 degrees decrease in the theta value since 1991. For the SEI 882 AB/ES2690 AC multiple star system, proper motion by the "A" component towards "C" and away from "B" has caused a 3.3% separation increase for "AB" and a 3.3% separation decrease for "AC" since 1991. In regards to SEI 1023, proper motion by the reference point star is responsible for 2.7% increase in the rho value since 1991.

Proper motions in opposite directions, by both of the components in three double stars, have caused noteworthy theta/rho shifts as well. The first such system to be mentioned is STF 2734, which has displayed a position angle increase of approximately 2.8 degrees since 1991. The second system in this category is WFC 384, which has had only one previous set of measurements in 1895. Partly as a result of this long time period between measurements, a 2.2 degrees theta decrease and a 26% rho increase are being reported. The third such system to be highlighted is A 3108 AB-CD. In this case, a 3.3% separation increase between "AB" and "CD" has occurred since 1991.

Another situation pertaining to "WFC" double stars is being highlighted in this report. While specific work is being done on the "WFC" doubles, it has been noticed that WFC 378 (21063+3839) and STF 2758 AB (21069+3845), also known as 61 Cygni, appear to be the same double star. This conclusion is based upon similarity of coordinates, magnitudes of the components, and theta/rho positions from 1895. Additionally, since there are no other bright double stars in that part of the sky, this would seem to confirm the existence of a duplicate entry in the WDS CATALOG.

As was mentioned in the last report, this one also contains measurements implying that a recent position angle listing in the WDS CATALOG might be anomalous for unknown reasons. Specifically, STF

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232 is listed as having a CATALOG theta value of 75 degrees in 1995, but measurements in 1832, my measurements, and values from the Hipparcos/Tycho Catalogs cluster around a value of 66 degrees. Because these component stars are relatively fixed, the 1995 theta value appears to be all the more suspect. Additional measurements by others would help to determine if this is the case.

Finally, the position angle measurement that is given in the table, for S 750, appears with a value that is deviant from other catalogs listings. While the WDS CATALOG and the Hipparcos/Tycho Catalogs indicate a p.a. value of around 321 degrees, my measurements match up more closely with the 1825 value of 323 degrees. The micrometer was recalibrated during the measuring process to insure that accurate measurements were being obtained for this pair, but the subsequent measurements remained consistent with the initial values. Because the proper motions of the component stars should cause the theta value to decrease, the reason for this discrepancy is unknown.

NAME	RA DEC	MAGS	PA	SEP	DATE	N	NOTES
HLM 25	19320+5259	8.9 9.6	253.8	11.85	2004.751	1n	1
STF2537	19336-0411	9.2 9.5	140.4	20.24	2004.751	1n	2
HJ 5128 AB	19336-1837	8.3 10.4	111.2	21.23	2004.751	1n	3
HJ 1418 AB	19337+5003	9.3 10.2	12.2	30.12	2004.751	1n	4
AG 232	19346+3518	9.2 10.3	278.0	10.86	2004.751	1n	5
STF2544 AC	19371+0819	8.6 9.9	236.9	13.83	2004.751	1n	6
AG 388	19384+5211	9.7 9.9	185.2	7.90	2004.751	1n	7
HJ 893	19395+1012	9.3 10.0	189.7	7.90	2004.754	1n	8
STF2563 AB	19425+1726	8.6 9.5	285.9	5.93	2004.754	1n	9
STF2563 AC	19425+1726	8.6 9.3	321.3	82.95	2004.754	1n	9
HJ 895 AC	19429+0115	8.5 9.6	24.1	30.12	2004.754	1n	10
HO 579 AC	19436-0904	9.2 10.4	155.6	64.19	2004.757	1n	11
STF2565	19453-1314	9.2 9.3	40.3	5.43	2004.757	1n	12
HJ 897	19468+0845	9.7 10.2	290.1	13.83	2004.757	1n	13
AG 239	19478+5154	8.6 9.8	239.6	15.80	2004.751	1n	14
HDS2814	19480-1434	8.5 10.5	139.1	18.27	2004.770	1n	15
KU 124	19487+2048	9.8 10.5	283.7	49.38	2004.770	1n	16
HU 77 AB-C	19506-1047	9.4 9.4	316.5	27.65	2004.770	1n	17
HJ 1443	19515+2522	10.0 9.9##	195.0	18.76	2004.770	1n	18
STF2591	19534-0600	8.7 9.1	106.9	29.63	2004.757	1n	19
STF2602 AB	19563-1321	9.3 9.8	147.8	12.34	2004.757	1n	20
ARG 35	19581+5355	9.0 9.9	226.1	7.41	2004.697	1n	21
KU 126	19583+3147	9.5 9.6	12.9	53.33	2004.697	1n	22
BU 1476 AC	19589-1318	9.5 10.0	193.1	132.33	2004.770	1n	23
ES 1970 AB	19591+3942	9.9 10.1	149.5	17.78	2004.697	1n	24
WFC 365	19593+2215	9.5 9.5	31.6	13.33	2004.699	1n	25
AG 397	20029+1056	8.8 9.6	113.6	28.64	2004.699	1n	26
STF2618	20034+1528	9.4 9.8	116.1	5.43	2004.699	1n	27

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NAME	RA DEC	MAGS	PA	SEP	DATE	N	NOTES
ARG 106	20054+5807	9.7 10.2	179.2	30.61	2004.699	1n	28
HJ 2934 CA	20057+5925	9.5 9.8	264.2	36.54	2004.699	1n	29
HJ 902	20066+0207	9.9 10.1	18.4	6.91	2004.699	1n	30
SEI 882 AB	20069+3115	8.8 10.5	60.5	33.58	2004.754	1n	31
ES 2690 AC	20069+3115	8.8 10.5	251.0	32.59	2004.754	1n	31
HJ 2936	20077+5908	9.5 10.3	250.7	12.84	2004.699	1n	32
SEI 926 AD	20094+3630	8.6 9.5	349.2	29.63	2004.697	1n	33
BLL 45	20095+4752	8.6 9.8	139.4	145.16	2004.697	1n	34
WFC 367	20102+4130	9.5 9.6	298.0	4.94	2004.699	1n	35
ES 87	20102+3644	9.3 10.3	298.0	8.89	2004.697	1n	36
SEI 958	20108+3646	10.0 10.0	323.5	21.73	2004.697	1n	37
ARG 36	20110+5717	8.7 9.9	128.2	7.90	2004.697	1n	38
STF2636	20117-0435	9.4 10.3	203.0	12.34	2004.757	1n	39
SEI1023	20136+3640	9.1 10.5	343.4	28.64	2004.754	1n	40
S 750	20299+2624	8.8 9.0	323.6	68.14	2004.754	1n	41
STF2692 AC	20310+2629	8.8 9.6	301.1	25.68	2004.754	1n	42
HJ 2974	20310+2007	9.6 9.8	296.6	14.32	2004.770	1n	43
HJ 2977	20329+1803	9.4 10.3	317.4	19.75	2004.770	1n	44
A 3108 AB-CD	20329+1357	9.1 9.9	340.3	96.78	2004.770	1n	45
ARN 83 #	20336+2106	8.4 9.1	73.4	58.26	2004.770	1n	46
WFC 374	20396+2018	8.6 10.0	319.7	6.42	2004.713	1n	47
HJ 922	20411+2133	9.7 9.7	312.3	7.41	2004.770	1n	48
HJ 921	20418-0430	9.4 9.6	219.9	9.38	2004.757	1n	49
HLD 40 AB	20434-1929	9.5 10.3	355.8	5.43	2004.757	1n	50
HLD 40 AC	20434-1929	9.5 10.1	257.9	144.18	2004.757	1n	50
BU 1302 AC	20448+2311	8.8 9.4	210.2	54.31	2004.757	1n	51
ES 1449	20452+4337	9.4 9.9	57.2	6.42	2004.754	1n	52
ES 2701	20459+4448	8.7 9.2	80.5	51.35	2004.713	1n	53
STF2725	20462+1554	7.5 8.1	11.7	6.42	2004.732	1n	54
ES 9006	20487+3334	9.0 10.4	94.0	25.68	2004.713	1n	55
HJ 926	20493+2026	9.3 9.9	190.5	5.93	2004.713	1n	56
HDS2970	20507-0929	8.9 10.0	114.1	14.81	2004.713	1n	57
ARG 40	20514+4519	9.3 10.2	251.2	9.38	2004.713	1n	58
ARG 41 AB	20515+5403	9.4 9.5	192.6	10.86	2004.713	1n	59
HJ 3001	20519-1631	9.8 10.4	241.4	6.91	2004.713	1n	60
STF2734	20541+1306	9.3 9.8	223.8	23.70	2004.713	1n	61
HJ 927	20565-0134	9.5 9.8	347.4	37.53	2004.713	1n	62
HWE 101 AB	20575+0036	9.1 10.1	138.9	40.49	2004.713	1n	63

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NAME	RA DEC	MAGS	PA	SEP	DATE	N	NOTES
AG 268	20582+0447	8.6 9.9	287.2	12.34	2004.713	1n	64
BU 764 AB-C	20588-0921	9.2 9.5	111.6	102.70	2004.713	1n	65
BU 764 AB-D	20588-0921	9.2 9.1##	22.2	136.28	2004.713	1n	65
BU 69 AC	21026+2141	8.1 7.9##	241.8	74.06	2004.732	1n	66
SEI1393	21047+3908	9.6 10.4	133.4	26.66	2004.732	1n	67
S 773	21048+3531	8.9 9.5	30.9	85.91	2004.732	1n	68
ENG 80 AC	21053+0704	8.4 9.0	106.4	169.36	2004.732	1n	69
ROE 45 AD	21061+4448	8.1 10.5	241.0	130.35	2004.732	1n	70
ROE 45 BC	21061+4448	10.3 10.5	238.2	123.44	2004.732	1n	70
STF2759	21065+3227	8.6 10.0	332.6	18.76	2004.732	1n	71
STF2758 AB	21069+3845	5.2 6.0	150.9	31.11	2004.732	1n	72
STF2758 AH	21069+3845	5.2 10.0	300.8	72.09	2004.732	1n	72
BU 988 AC	21070+4125	10.0 9.8##	11.5	9.38	2004.732	1n	73
STF2761	21074+2429	9.3 9.7	109.9	5.43	2004.732	1n	74
ABH 141 AD	21078+3421	8.5 10.2	222.6	84.93	2004.732	1n	75
AG 414	21082+4055	9.3 9.6	105.0	5.43	2004.732	1n	76
WFC 384	21391+4421	9.5 10.0	80.8	5.93	2004.713	1n	77
AG 274 AB	21396+2322	9.6 10.5	153.1	9.38	2004.699	1n	78
HJ 5298	21526-1548	9.0 10.2	318.3	66.16	2004.697	1n	79
HJ 616	21550-1158	8.1 10.5	275.0	30.61	2004.697	1n	80
ALL 4	21560+1948	9.2 9.7	207.6	19.26	2004.697	1n	81
BU 1214 AC	21566+3421	9.6 9.9	14.9	106.65	2004.697	1n	82
HJ 1932	00043+4235	8.6 9.4	307.5	6.91	2004.735	1n	83
ES 1488	00475+4214	9.1 9.7	280.9	6.91	2004.738	1n	84
STF 60 AB	00491+5749	3.5 7.4	320.3	12.84	2004.735	1n	85
STF 136 AB	01349+1234	7.3 8.3	77.3	15.31	2004.735	1n	86
STF 205 A-BC	02039+4220	2.1 5.0	63.5	9.88	2004.735	1n	87
WFC 15	02045+4750	9.9 10.3	119.8	5.43	2004.735	1n	88
STT 24 AB	02129+5712	7.0 8.7	332.0	88.88	2004.735	1n	89
STF 232	02147+3024	7.8 7.9	65.9	6.91	2004.735	1n	90
STT 25	02169+5703	6.5 7.4	204.9	101.71	2004.735	1n	91
STF 5	02370+2439	6.5 7.0	275.1	37.53	2004.735	1n	92
STF 296 AB	02442+4914	4.1 9.9	308.5	20.74	2004.735	1n	93
WFC 23	03040+4707	9.6 10.4	320.5	7.41	2004.735	1n	94
STF 412 AB-C	03344+2428	6.1 9.9	54.7	22.71	2004.735	1n	95

Not listed in the WDS CATALOG.

Companion star is the brighter component.

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Notes

1. In Cygnus. Common proper motion; p.a. decreasing. Spect. A0
2. In Aquila. Sep. & p.a. increasing. Spect. A0.
3. In Sagittarius. Relatively fixed. Spect. A8, A5.
4. In Cygnus. Sep. & p.a. increasing. Spect. K0.
5. In Cygnus. Relatively fixed. Common proper motion. Spect. F0, F0.
6. In Aquila. Sep. & p.a. decreasing. Spect. A3, A3.
7. In Cygnus. Relatively fixed. Common proper motion. Spect. G0, G0.
8. In Aquila. Position angle decreasing. Spect. K2.
9. In Sagitta. A, B, & C = relfixed; cpm. Spect. AC = G0, A2.
10. In Aquila. Sep. & p.a. increasing. Spect. G1V, A2.
11. In Aquila. Sep. & p.a. increasing. Spect. A0.
12. In Sagittarius. Common proper motion; p.a. increasing. Spect. K0III, G5.
13. In Aquila. Relatively fixed. Spect. G0, G0.
14. In Cygnus. Sep. increasing; p.a. decreasing. Spect. K2, G5.
15. In Sagittarius. Sep. & p.a. increasing. Spect. B9IV, B9IV.
16. In Vulpecula. Sep. decreasing; p.a. increasing. Spect. K0, B8.
17. In Aquila. Sep. & p.a. decreasing. Spect. K0, K2.
18. In Vulpecula. Relatively fixed. Spect. A3.
19. In Aquila. Common proper motion; p.a. decreasing. Spect. F8, G0.
20. In Sagittarius. Position angle decreasing. Spect. B9.5V, A0.
21. In Cygnus. Relatively fixed. Common proper motion. Spect. G5, F2.
22. In Cygnus. Relatively fixed. Spect. F8, A2.
23. In Sagittarius. Separation slightly increasing. Spect. K7, K5.
24. In Cygnus. Separation decreasing.
25. In Vulpecula. Common proper motion. Sep. & p.a. increasing. Spect. K2, K2.
26. In Aquila. Position angle increasing. Spect. G5, A0.
27. In Aquila. Relatively fixed. Spect. A0.
28. In Cygnus. Common proper motion; sep. increasing. Spect. F8.
29. In Cygnus. Common proper motion; p.a. increasing. Spect. K7, K0.
30. In Aquila. Relatively fixed. Spect. F8.
31. In Cygnus. AB = sep. inc, p.a. dec. AC = sep. dec. Spect. AB = F7V, G0.
32. In Cygnus. Position angle decreasing. Spect. A0, A0.
33. In Cygnus. Relatively fixed. Spect. B0I.
34. In Cygnus. Relatively fixed. Spect. N4, K0.
35. In Cygnus. Relatively fixed. Common proper motion.
36. In Cygnus. Separation decreasing. Spect. A0V.
37. In Cygnus. Position angle decreasing. Spect. B8IV.
38. In Cygnus. Relatively fixed. Common proper motion. Spect. F8.
39. In Aquila. Relatively fixed. Common proper motion. Spect. A0.
40. In Cygnus. Separation increasing. Spect. A7III.
41. In Vulpecula. Separation slightly increasing. Spect. K0, K0.
42. In Vulpecula. Relatively fixed. Common proper motion. Spect. A0, A0.
43. In Delphinus. Position angle increasing. Spect. K2, K.
44. In Delphinus. Sep. increasing; p.a. decreasing. Spect. M2, K.
45. In Delphinus. Sep. increasing; p.a. decreasing. Spect. F8, K0.
46. In Vulpecula. Separation decreasing. Spect. K2, K2.
47. In Vulpecula. Position angle slightly decreasing. Spect. F8.
48. In Vulpecula. Common proper motion; p.a. increasing. Spect. F5, F5.
49. In Aquarius. Relatively fixed. Common proper motion. Spect. G0.
50. In Capricornus. AB = p.a. dec. AC = relfix; common proper motion. Spect. F7.
51. In Vulpecula. Sep. & p.a. increasing. Spect. A0, F5.

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52. In Cygnus. Position angle increasing. Spect. A2, A.
53. In Cygnus. Separation decreasing. Spect. A7V, F0.
54. In Delphinus. Sep. & p.a. increasing. Spect. K0, K0.
55. In Cygnus. Relatively fixed. Spect. A2.
56. In Vulpecula. Sep. & p.a. dec. Common proper motion. Spect. G0, G0.
57. In Aquarius. Relatively fixed. Spect. G0, G0.
58. In Cygnus. Position angle slightly increasing. Spect. A5, F.
59. In Cygnus. Sep. & p.a. increasing. Spect. F0.
60. In Capricornus. Relatively fixed. Spect. F6V.
61. In Delphinus. Sep. decreasing; p.a. increasing. Spect. G0, G0.
62. In Aquarius. Separation increasing. Spect. F8.
63. In Aquarius. Separation slightly decreasing. Spect. A5.
64. In Equuleus. Relatively fixed. Spect. A2.
65. In Aquarius. AB-C = Sep. inc. AB-D = Sep. dec. Spect. F8, G0, G0.
66. In Vulpecula. Sep. decreasing; p.a. increasing. Spect. F0, K0.
67. In Cygnus. Sep. & p.a. decreasing.
68. In Cygnus. Separation slightly increasing. Spect. M0, K0.
69. In Equuleus. Sep. & p.a. decreasing. Spect. K5, F0.
70. In Cygnus. AD = sep. increasing. BC = sep. slightly decreasing. Spect. K0.
71. In Cygnus. Sep. & p.a. increasing. Spect. G5, G.
72. 61 Cygni. AB = sep. & p.a. inc. Aa = p.a. dec. Spect. AB = K5V, K7V.
73. In Cygnus. Sep. & p.a. decreasing. Spect. F8, K.
74. In Vulpecula. Position angle slightly decreasing. Spect. A2, A2.
75. In Cygnus. Relatively fixed. Spect. M0.
76. In Cygnus. Position angle decreasing. Spect. F5, F5.
77. In Cygnus. Sep. increasing; p.a. decreasing. Spect. A0.
78. In Pegasus. Relatively fixed. Common proper motion. Spect. F8, F8.
79. In Capricornus. Sep. & p.a. increasing. Spect. K0IV.
80. In Capricornus. Relatively fixed. Common proper motion. Spect. A2.
81. In Pegasus. Sep. & p.a. increasing. Spect. G0, G0.
82. In Pegasus. Sep. & p.a. decreasing. Spect. A0.
83. In Andromeda. Sep. slightly decreasing; p.a. increasing. Spect. F5V, F7V.
84. In Andromeda. Position angle decreasing. Spect. A3.
85. Eta or 24 Cassiopeiae. Sep. & p.a. increasing. Spect. F8, G0V.
86. In Pisces. Common proper motion; p.a. slightly decreasing. Spect. A6V, F5.
87. Gamma Andromedae. Sep. slightly dec; cpm. Spect. K3II, B8V.
88. In Perseus. Common proper motion; p.a. increasing. Spect. F8, F8.
89. In Perseus. Separation increasing. Spect. G2V, G0.
90. In Triangulum. Relatively fixed. Common proper motion. Spect. A0V, A0V.
91. In Perseus. Separation slightly decreasing. Spect. B1I, B1.
92. 30 Arietis. Relatively fixed. Common proper motion. Spect. F5V, F7V.
93. Theta or 13 Persei. Sep. & p.a. increasing. Spect. F8, M1V.
94. In Perseus. Separation slightly increasing.
95. 7 Tauri. Position angle increasing. Spect. A2V.

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Abstract: This report contains theta/rho measurements from 97 different double star systems. The time period spans from 2004.902 to 2005.290. All measurements were obtained using a 20-cm Schmidt-Cassegrain telescope and an illuminated reticle micrometer. This report represents a portion of the work that is currently being conducted in double star astronomy at Divinus Lux Observatory in Flagstaff, Arizona.

At the point in time when this article has been written, 2,678 theta/rho measurements of double stars have been completed at Divinus Lux Observatory. In addition, 88 new discoveries, including some new double stars and some additional components for currently cataloged systems, have been recorded. This work has been accomplished as the result of a double star research project that has been in progress since April of 2001.

The reason for mentioning this is to highlight the fact that a substantive double star measuring program can be conducted with the use of modest instrumentation. The intent is not to boast about what has been accomplished at Divinus Lux Observatory to date, but to encourage any reader of this article who may still have doubts about the possibly of conducting valuable research in double star astronomy with limited equipment. There is much more research that needs to be done by those who have the inclination for it, and this need is too large to be filled by any one individual, including myself.

As has been done in previous articles, the selected double star systems, which appear in this report, have been taken from the 2001.0 version of the Washington Double Star Catalog, with published measurements that are no more recent than ten years ago. Exceptions to this stipulation include the following: STF 305 AB, STF 742, STF 982 AB, STF 1110 AB, STF 1196 AB-C, STF 1321 AB, STF 1424 AB, STF 1785, STF 1888 AB, STF 1954 AB, STF 1788AB, STF 2032 AB, and STF 2021 Aa-B. The reason for these exceptions is because the theta/rho shifts for these visual binaries are large enough to warrant more frequent measurements. There are also some noteworthy items that are mentioned in reference to the following table.

To begin with, the reader may wonder why STF 17 is included as part of the STF 16 multiple star system. The reason is that STF 16 and STF 17 share the same reference point star, Theta 2 Orionis, and the coordinates for both systems are identical. To confuse matters even more, the companion star for STF 17 is also the reference point star for the STF 748 multiple star system. Considering the overlapping that has occurred with these designations, one might question whether it is meaningful to retain the label of STF 17, or whether this should be eliminated or reconfigured. In addition, while the STF 16/17 multiple star system has the appearance of being relatively fixed among all of the brighter components, the position angle measurement for STF 17, which is listed in the table, indicates an increase of 2 degrees since the last published measurements in 1995. While care was taken to be as accurate as possible, the p.a. listing in the table needs additional confirmation since this measurement appears to be so anomalous.

Anomalous position angle measurements appear to be a factor for five additional double star systems. For WFC 64, the theta catalog measurements for 1933 appear to be at a variance from other position angle decreases that have been recorded, which were caused by proper motion. A decrease of 5 degrees in the theta value, from 1899 to the present, seems consistent with proper motion shifts, while the 1933 measurements indicate an increase of 5 degrees since 1899. More measurements for this system would help to confirm that the position angle is actually decreasing.

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The second position angle anomaly pertains to WFC 60. In this case, the theta measurements have varied from 291 to 294 degrees from 1894 to the present, but this system is supposed to be relatively fixed. Because of the array of values that have been recorded over the past one hundred years, this is another double star that needs additional measurements in order to determine the theta value more accurately.

Thirdly, various theta/rho values have also been recorded for WFC 284. From 1897 to the present, theta values have ranged from 157 to 161 degrees, while rho values have ranged from 7.8" to 8.4". Because only a meager number of measurements exist for this common proper motion pair, this is another system that needs additional study.

The fourth position angle anomaly that I would like to highlight is in reference to STF 3118 AC. In this case, catalog p.a. measurements from 1897and 1991, and from the Hipparcos/Tycho data, seem to agree within a degree. However, when I measured this pair, a value was obtained that was 3.5 degrees greater than from these other sources. My position angle measurements for STF 3118 AD displayed no such variance, and the micrometer was recalibrated while measuring AC to provide a reality check. Since the cause for this phenomenon has not been determined, additional measurements of the AC components would help to either confirm the catalog value of 334 degrees, or the value of 337.5 degrees that I have obtained.

The final p.a. irregularity to be noted is in reference to STF 1807. WDS CATALOG measurements for this double star include a value of 26 degrees in 1831 and 24 degrees in 1995. The Hipparcos/Tycho listing indicates a value of 27.5 degrees, while the theta measurement that appears in this report is listed at 28.1 degrees. Additional measurements would, hopefully, help to establish which theta value is the most accurate.

As has been mentioned in past reports, this one also contains theta/rho shifts, which are listed in the table, that have been caused by the proper motions of one or both of the component stars in a given system. One such double star to fit this category is HJ 2352. Because of proper motion by the reference point star, the separation value has increased by 2.2% since 1991.

A large proper motion by the "A" component of STF 1263 AB is responsible for increases of almost 2 degrees in position angle and 7+ seconds in separation since 1995. This double star is in an obvious optical alignment. Proper motions by the "AB" components toward the "C" component, in the H27 multiple star system, are the cause for a 5% decrease in separation since 1991. Because "AB" is a close and faint pair, I was not able to cleanly resolve these two components. Consequently, my measurements more accurately reflect parameters for "AB-C" rather than for "AC." Therefore, the table lists the measurements for H 27 AC as H 27 (AB-C). Measurements for "AB-C" are not listed in the WDS CATALOG. Finally, S 598 AB has shown a decrease of 3 % in separation, since 1995, because of proper motion by the "A" component.

The last item that needs to be mentioned has to do with some measurements, which are recorded in the WDS CATALOG, that appear to be erroneous. These errors pertain to the listings for "AE" and "AF" in the STF 1543 multiple star system (11291+3920). These two listings are duplicates of the correctly listed measurements for "DE" and "DF." The Hipparcos/Tycho star charts confirm that "D" is the actual reference point star for these measurements, rather than "A."

Name	RA Dec	Mags	PA	Sep	Date	N	Notes
STF 305 AB	02475+1922	7.5 8.2	307.0	3.46	2005.096	1n	1
STF 654 AB	05133+0252	4.5 8.5	64.0	6.91	2004.902	1n	2
STF 696	05228+0333	5.0 6.8	29.1	32.59	2004.902	1n	3
STF 14 Aa-C	05320-0018	2.4 6.9	0.7	53.33	2004.902	1n	4
STF 718 AB	05323+4924	7.4 7.5	73.9	7.90	2004.902	1n	5
STF 16 AB	05354-0525	5.0 6.2	93.3	52.83	2004.902	1n	6
STF 16 AC	05354-0525	5.0 8.5	99.1	128.38	2004.902	1n	6
STF 17	05354-0525	5.0 5.1	316.1	133.31	2004.902	2n	6

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Name	RA Dec	Mags	PA	Sep	Date	N	Notes
STF 742	05364+2200	7.4 7.8	274.5	3.95	2005.096	1n	7
STT 65 AB	05379+0058	7.5 8.0	31.5	79.99	2004.904	1n	8
S 502	05547+1351	7.9 8.3	131.1	45.92	2004.904	1n	9
STF 873	06126-0118	9.7 10.4	293.2	8.89	2004.945	1n	10
A 666 AB-C	06133-0624	8.4 9.1	320.7	230.09	2004.945	1n	11
STT 71	06145+1148	7.1 7.6	312.7	89.86	2004.904	1n	12
BRT 376	06160-0745	9.4 9.4	115.3	5.93	2004.945	1n	13
STT 73 AB	06194+1326	6.9 7.6	44.0	72.09	2004.904	1n	14
HJ 386 AB	06219+2731	9.7 10.4	64.9	21.73	2004.945	1n	15
HJ 386 AC	06219+2731	9.7 9.6##	166.1	56.29	2004.945	1n	15
S 517 AB	06222-1636	8.7 8.7	192.1	22.71	2004.948	1n	16
HJ 728	06265-0150	9.1 10.1	264.2	27.16	2004.945	1n	17
HJ 731	06308-0939	8.9 10.0	34.0	11.85	2004.945	1n	18
WFC 56	06314-1234	6.8 9.9	171.1	19.26	2004.967	1n	19
BAL1315	06321+0130	9.9 10.4	140.0	12.84	2004.945	1n	20
HJ 2322	06337+0155	9.9 9.9	319.5	16.79	2004.948	1n	21
STF 918 AB	06340+5228	7.2 8.2	333.9	4.94	2004.904	1n	22
STF 918 AC	06340+5228	7.2 10.3	24.7	145.16	2004.904	1n	22
HJ 734	06359-0927	9.8 9.8	33.0	7.90	2004.948	1n	23
STF 940	06373+3826	8.7 10.2	294.2	10.37	2004.945	1n	24
AG 118	06391+0220	8.8 10.3	306.3	35.55	2004.964	1n	25
S 528 AB	06393+3135	8.7 10.3	27.0	82.95	2004.945	1n	26
WFC 60	06398-0358	10.1 10.2	291.5	9.88	2004.964	1n	27
ABH 50 AD	06406+0947	8.5 9.0	137.1	103.69	2004.948	1n	28
POU1883 AB	06414+2336	9.5 10.4	24.8	17.78	2004.964	1n	29
STF3118 AC	06415+0950	9.8 7.5##	337.5	94.80	2004.964	1n	30
STF3118 AD	06415+0950	9.8 9.9	31.8	128.38	2004.964	1n	30
GAL 410	06426-0934	8.5 9.9	26.0	19.75	2004.964	1n	31
J 2009	06449+0728	8.6 9.9	37.9	7.90	2004.964	1n	32
STF 959	06450+1346	9.8 10.1	175.1	11.85	2004.964	1n	33
BAL1717	06456+0219	9.7 9.9	10.2	8.89	2004.964	1n	34
WFC 64	06461+3323	10.1 9.7##	18.4	4.44	2004.964	1n	35
STF 965 AD	06473+1055	8.9 9.4	58.4	41.97	2004.964	1n	36
STF 970	06478-1143	9.1 9.6	127.9	20.24	2004.964	1n	37
STF 962	06482+2642	9.2 9.5	242.1	25.68	2004.948	1n	38
HJ 2347	06513+0533	9.8 10.2	21.7	21.73	2004.964	1n	39
HJ 2352	06540+0034	9.8 10.4	26.8	23.70	2004.967	1n	40
STF 988	06540-1002	9.4 9.7	265.0	33.58	2004.967	1n	41

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Name	RA Dec	Mags	PA	Sep	Date	N	Notes
STT 79	06541+0641	7.1 7.5	88.8	115.54	2004.904	1n	42
STF 982 AB	06546+1311	4.7 7.8	145.4	7.41	2004.948	1n	43
STF 992	06556-0929	8.6 9.8	301.2	13.83	2004.967	1n	44
STF 993	06558-1152	8.9 8.9	240.3	36.54	2004.967	1n	45
H 27(AB-C)	06561+2005	9.5 9.7	152.9	23.70	2004.981	1n	46
RST3475 A-BC	06564-1016	9.7 10.1	158.9	19.75	2004.967	1n	47
KU 92	07006+0921	9.6 10.0	322.1	46.41	2004.967	1n	48
WFC 73	07024-0508	9.7 9.9	201.2	8.89	2004.981	1n	49
STF1002 AB-C	07042+5626	9.4 10.0	318.1	30.61	2004.967	1n	50
ES 900	07042+4957	9.7 10.2	52.2	9.88	2004.981	1n	51
J 1465	07046-0717	9.7 10.1	289.3	8.89	2004.981	1n	52
STF1015	07049-0547	9.4 9.4	198.5	4.94	2004.981	1n	53
J 702 AC	07098+0526	9.6 10.0	168.9	61.23	2004.981	1n	54
HJ 2359	07099+5806	9.4 10.0	19.3	30.61	2004.984	1n	55
STF1020	07119+5730	8.7 10.4	284.9	12.84	2004.984	1n	56
STF1025 AB	07128+5548	8.2 8.5	129.8	26.66	2004.967	1n	57
WFC 77	07143+0307	5.3 9.9	319.2	51.35	2004.967	1n	58
HJ 419	07221-0402	9.2 10.5	40.3	7.90	2004.984	1n	59
STF1080	07223+0429	10.0 10.4	221.1	22.22	2004.984	1n	60
STT 84 AB	07254+5633	7.5 7.7	324.0	113.56	2004.967	1n	61
STF1101	07287-1349	9.5 9.7	88.5	6.42	2004.984	1n	62
ENG 31 AB	07299+4940	5.4 10.0	304.4	179.73	2005.060	1n	63
STF1114	07337+0917	9.2 9.9	53.0	6.42	2004.984	1n	64
HJ 56	07343-0313	9.5 9.8	148.9	6.91	2004.984	1n	65
STF1110 AB	07346+3153	1.9 3.0	62.2	4.44	2004.967	1n	66
STT 87	07389+4229	7.7 7.5##	177.3	62.21	2004.967	1n	67
STT 89	07510+3137	6.8 7.7	83.4	77.03	2004.967	1n	68
STF1178	08034-1312	9.2 9.3	329.1	5.43	2005.060	1n	69
STF1196 AB-C	08122+1739	5.2 5.8	70.0	5.93	2004.981	1n	70
S 565 AB	08247+4200	6.0 8.5	176.1	83.94	2004.981	1n	71
S 566	08265+2754	5.6 10.6	21.4	139.24	2004.981	1n	72
STF1263 AB	08452+4140	8.5 9.2	22.8	128.38	2004.981	1n	73
SHJ 101	09018+2754	6.1 9.1	329.6	103.69	2005.041	1n	74
STF1321 AB	09144+5241	7.6 7.7	94.3	17.28	2005.041	1n	75
S 598 AB	09287+4536	5.4 7.7	161.5	70.11	2005.041	1n	76
STF1424 AB	10200+1950	2.2 3.2	125.5	4.44	2005.041	1n	77
STF1472	10470+1302	8.4 9.4	34.5	42.36	2005.156	1n	78
STF1543 AD	11291+3920	5.4 7.6	252.8	343.65	2005.156	1n	79

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Name	RA Dec	Mags	PA	Sep	Date	N	Notes
STT 114	12002+3644	7.5 8.3	83.2	86.90	2005.156	1n	80
STF1740	13237+0243	7.1 7.3	74.9	26.66	2005.216	1n	81
H 70 AC	13309+2414	7.6 8.2	256.5	75.05	2005.216	1n	82
STF1785	13491+2659	7.2 8.0	178.0	3.46	2005.216	1n	83
STF1788 AB	13550-0804	6.6 7.2	98.7	3.46	2005.274	1n	84
STF1807	14113-0320	8.4 8.7	28.1	7.41	2005.216	1n	85
STF1833 AB	14226-0746	7.5 7.5	174.3	5.93	2005.216	1n	86
STF1873	14448+0742	7.9 8.3	92.5	6.91	2005.255	1n	87
STF1888 AB	14514+1906	4.7 6.8	312.9	6.42	2005.255	1n	88
STF1919	15127+1917	6.6 7.3	10.6	23.70	2005.255	1n	89
STF1939	15275-1058	8.2 9.2	130.8	9.88	2005.255	1n	90
STF1954 AB	15348+1032	4.1 5.1	172.9	4.44	2005.255	1n	91
STF2021 Aa-B	16133+1332	7.3 7.7	356.1	4.44	2005.290	1n	92
STF2032 AB	16147+3352	5.6 6.4	237.7	7.41	2005.290	1n	93
H 38	16229+3220	6.4 9.7	16.5	31.58	2005.290	1n	94
STF2044	16242+3702	8.3 8.7	339.8	8.39	2005.290	1n	95
WFC 284	16255+1944	10.6 10.5##	339.8	7.90	2005.290	1n	96
STF2098 AB	16457+3000	8.7 9.5	144.5	14.32	2005.290	1n	97
STF2098 AC	16457+3000	8.7 8.8	128.7	66.16	2005.290	1n	97

Companion star is the brighter component.

Notes

1. In Aries. Common proper motion; p.a. decreasing. Spect. G0, G0.
2. Rho or 17 Orionis. Separation slightly decreasing. Spect. K2III, K3III.
3. In Orion. Sep. & p.a. increasing. Spect. B1V, B3V.
4. Delta or 34 Orionis. Relatively fixed. Spect. B4, B0.
5. In Auriga. Relatively fixed. Common proper motion. Spect. F5, F5.
6. Theta 2 or 43 Orionis. Relatively fixed system. Spect. O9.5V, B, B8, O6.
7. In Taurus. Common proper motion, p.a. increasing. Spect. F8.
8. In Orion. Relatively fixed. Spect. B6V, B9.
9. In Orion. Relatively fixed. Spect. O6, A0.
10. In Orion. Relatively fixed. Spect. G, G.
11. In Monoceros. Relatively fixed. Spect. G5, K0.
12. In Orion. Position angle slightly increasing. Spect. K0, A0.
13. In Monoceros. Sep. & p.a. increasing. Spect. A2.
14. In Orion. Possible common proper motion. Sep. decreasing. Spect. F6V, K1V.
15. In Gemini. AB = sep. inc. AC = cpm. Spect. AC = F2V, F5.
16. In Canis Major. Relatively fixed. Spect. A5.
17. In Monoceros. Sep. & p.a. increasing. Spect. K0, G.
18. In Monoceros. Relatively fixed. Spect. B8.
19. In Canis Major. Relatively fixed. Spect. B5.
20. In Monoceros. Relatively fixed. Spect. A0, A0.
21. In Monoceros. Position angle increasing. Spect. A0.

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22. In Auriga. AB = cpm, p.a. inc. AC = optical. Spect. AB = A3, A3.
23. In Monoceros. Relatively fixed. Spect. B9.
24. In Auriga. Relatively fixed. Spect. A5.
25. In Monoceros. Relatively fixed. Spect. B9.
26. In Auriga. Separation slightly increasing. Spect. F5.
27. In Monoceros. Relatively fixed. Common proper motion.
28. In Monoceros. Relatively fixed. Spect. B3V, B8.
29. In Gemini. Position angle decreasing. Spect. A, A.
30. In Monoceros. AC & AD = sep. decreasing. Spect. AC = A2, B5.
31. In Monoceros. Relatively fixed. Spect. A0, A0.
32. In Monoceros. Sep. increasing; p.a. decreasing. Spect. A2.
33. In Gemini. Relatively fixed. Common proper motion. Spect. G5.
34. In Monoceros. Relatively fixed. Spect. A0.
35. In Gemini. Position angle decreasing.
36. In Monoceros. Sep. & p.a. decreasing. Spect. G0, F0.
37. In Canis Major. Relatively fixed. Common proper motion. Spect. F8, G.
38. In Gemini. Relatively fixed. Spect. G0, A0.
39. In Monoceros. Position angle increasing. Spect. F0.
40. In Monoceros. Sep. & p.a. increasing. Spect. F8.
41. In Monoceros. Relatively fixed. Common proper motion. Spect. A2, A0.
42. In Monoceros. Relatively fixed. Spect. G5, A0.
43. 38 Geminorum. Sep. increasing; p.a. decreasing. Spect. F0, F0.
44. In Monoceros. Position angle increasing. Spect. G0.
45. In Canis Major. Position angle increasing. Spect. F0, F.
46. In Gemini. Sep. & p.a. decreasing. Spect. A2, A0.
47. In Monoceros. Relatively fixed. Spect. K0, K0.
48. In Monoceros. Separation increasing. Spect. A, K7.
49. In Monoceros. Relatively fixed. Common proper motion. Spect. A0.
50. In Lynx. Relatively fixed. Common proper motion. Spect. G, F8.
51. In Lynx. Sep. & p.a. decreasing. Spect. F, A2.
52. In Monoceros. Sep. & p.a. increasing. Spect. A0.
53. In Monoceros. Position angle slightly increasing. Spect. A0, A0.
54. In Canis Minor. Relatively fixed. Spect. A0.
55. In Lynx. Position angle increasing. Spect. K2, G5.
56. In Lynx. Relatively fixed. Common proper motion. Spect. F5.
57. In Lynx. Sep. increasing; p.a. decreasing. Spect. K0, K0.
58. In Canis Minor. Relatively fixed. Spect. G5, G0.
59. In Monoceros. Common proper motion; p.a. decreasing. Spect. F5.
60. In Canis Minor. Relatively fixed. Common proper motion. Spect. A2, G0.
61. In Lynx. Position angle decreasing. Spect. K2, F8.
62. In Puppis. Relatively fixed. Spect. A5IV.
63. 22 Lyncis. Separation increasing. Spect. F6V.
64. In Canis Minor. Relatively fixed. Spect. G5.
65. In Monoceros. Position angle decreasing.
66. Castor or 66 Geminorum. Sep. increasing; p.a. decreasing. Spect. A0, A2V.
67. In Lynx. Sep. & p.a. decreasing. Spect. F5, F5.
68. In Gemini. Relatively fixed. Common proper motion. Spect. A6III, A5.
69. In Puppis. Relatively fixed. Common proper motion. Spect. K0III, K0III.
70. Zeta or 16 Cancri. Sep. increasing; p.a. decreasing. Spect. G0, G0V.
71. In Lynx. Sep. & p.a. increasing. Spect. K5III, K.
72. Phi 1 or 22 Cancri. Separation increasing. Spect. K5III.

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73. In Lynx. Sep. & p.a. increasing. Spect. K3V, G5.
74. 67 Cancri. Sep. & p.a. increasing. Spect. A8V, K7.
75. In Ursa Major. Sep. decreasing; p.a. increasing. Spect. K2, K2.
76. In Ursa Major. Separation decreasing. Spect. K0III, F8.
77. Gamma or 41 Leonis. Sep. & p.a. increasing. Spect. K0III.
78. In Leo. Sep. increasing; p.a. decreasing. Spect. K0, K0.
79. 57 Ursae Majoris. Separation decreasing. Spect. A2V, K0.
80. In Ursa Major. Position angle slightly increasing. Spect. A0, K2.
81. In Virgo. Relatively fixed. Common proper motion. Spect. G5V, G5V.
82. In Coma Berenices. Sep. increasing; p.a. decreasing. Spect. G2III, G5.
83. In Bootes. Position angle increasing. Spect. K4V, K6V.
84. In Virgo. Sep. & p.a. increasing. Spect. F8V, F8.
85. In Virgo. Common proper motion. Spect. F8, F8.
86. In Virgo. Common proper motion; p.a. increasing. Spect. G0V, G0V.
87. In Virgo. Relatively fixed. Spect. G5III, F5.
88. Xi or 37 Bootis. Sep. & p.a. decreasing. Spect. G8II, K5V.
89. In Serpens. Relatively fixed. Common proper motion. Spect. G1V, G5V.
90. In Libra. Common proper motion; p.a. decreasing. Spect. G0, G0.
91. Delta or 13 Serpentis. Sep. increasing; p.a. decreasing. Spect. F0IV, F0IV.
92. In Hercules. Position angle increasing. Spect. G9V.
93. Sigma or 17 Coronae Borealis. Sep. & p.a. increasing. Spect. G0V, G1V.
94. In Corona Borealis. Sep. & p.a. decreasing. Spect. A4V, A2.
95. In Hercules. Common proper motion; p.a. decreasing. Spect. K0, K0.
96. In Hercules. Common proper motion. Relatively fixed?
97. In Hercules. AB = cpm. AC = p.a. decreasing. Spect. F2V, F0, F0.

Unreported High Proper Motion Northern Double Stars in the LSPM Catalog

Part 1 - Stars to 90 arc seconds separation

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Abstract: Data mining the LSPM catalog has yielded 51 previously unreported double stars in the northern sky with each pair showing a large shared proper motion.

Introduction

It is always exciting when a new catalog is made available through the Vizier system. All the more so when, in July 2005, a detailed survey of high proper motion stars appeared.

The LSPM catalog, Lepine+ 2005, is a comprehensive list of 61,977 stars north of the J2000 celestial equator that have proper motions larger than 0.15"/yr (local-background-stars frame). All the northern stars listed in the Luyten Half-Second and New Luyten Two-Tenths catalogs have been re-identified and positions, proper motions and magnitudes re-evaluated. Positions are given with an accuracy of <~100mas at the 2000.0 epoch and absolute proper motions are given with an accuracy of ~8 mas/yr. Corrections to the local-background-stars proper motions have been calculated and absolute proper motions in the extragalactic frame are given. The LSPM data can be accessed via the Vizier web pages at:

http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=I/298

Methodology

Once the positional data has been downloaded the mathematics involved in calculating the separation and position angle between two stars is relatively simple.

Using RA (α) and Dec (δ) values in decimal degrees:

$$\Delta\delta = (\delta_2 - \delta_1)$$

$$\Delta\alpha = (\alpha_2 - \alpha_1)\cos(\delta_1)$$

Then, the separation (ρ) and position angle (θ) are given by

$$\rho = \sqrt{(\Delta\delta)^2 + (\Delta\alpha)^2}$$
$$\theta = \arctan(\Delta\alpha \,/\, \Delta\delta)$$

The three main complications are the quantity of data to be processed, the fact that astronomical position angle is measured from north in an anti-clockwise direction and that arctan yields two results, 180 degrees apart, if only positional data is used in the calculation. These problems were resolved by using a computer to aid data processing, by a simple arithmetical tweak to convert *Microsoft Excel* angles to the format required by astronomers and by combining positional data with magnitude data so that only position angles measured from the brighter to the fainter source were reported.

Purpose built software (Nicholson, 2005), written by C Whiting, was used to carry out the initial analysis. The method used was as follows:

- The stars were arranged in order by right ascension.

Unreported High Proper Motion Northern Double Stars in the LSPM Catalog

- The software then calculated the distance between any given star and its neighbours in this list. If the distance was greater than 90 arc seconds then no further processing was done because, regardless of the declination, no two stars differing by more than 90 arc seconds in right ascension could possibly lie within a total of 90 arc seconds of each other.
- For pairs of stars found to be within 90 arc seconds in right ascension the declination was then used to calculate the total distance between the two stars. If the total distance was greater than 90 arc seconds no further processing was done.
- For pairs of stars within a total of 90 arc seconds the position angle was calculated using the standard formula and measuring from the brighter star to the fainter star.
- The resulting data was then written to a standard text tile in the format agreed between the programmer and myself.

The 15,286 stars of magnitude 14.0 or brighter yielded 429 "candidate pairs" of stars. This figure needed to be compared with the result that would be obtained on a purely random basis.

Imagine you have a catalogue that contains N stars and these are uniformly distributed across the northern hemisphere of the sky (2.675×10^{11} as^2) then the probability of having a star in any one arc second area, P_a, is $N / 2.675 \times 10^{11}$.

In the case of the LSPM, N = 15,288. This gives a value of $P_s = 5.75 \times 10^{-8}$.

The probability that there no other stars within a radius of r arc seconds is:

$$P = (1 - P_a)^A$$

where A = the area of the circle surrounding the star

The upper limit of 90 arc seconds, following the example of Greaves (2004), was chosen since the aim of this initial experiment was to find strong candidates for common proper-motion pairs rather than larger numbers of far less certain associations.

The probability that there is no companion within 90 arc seconds is 99.85%. This means that 0.15% of stars would be expected, on a purely random basis, to have a companion within this distance. This is equivalent to approximately 11 pairs with separations between 0 and 90 arc seconds.

The 429 "candidate pairs" were not all new discoveries – following filtering to remove those already recorded in the LDS Catalogue: Doubles with Common Proper Motion (Luyten 1940-87) and in the Washington Visual Double Star Catalog, 1996.0 (Worley+, 1996) the number was reduced to 72 pairs.

The candidates were then checked against two further criteria:

1. If the difference in the quoted proper motion for the two stars in right ascension or declination was >0.016 arcsec/yr (twice the quoted error) the pair was eliminated. 21 pairs were eliminated at this stage.
2. If the pair was found to be within 30 arcmin of the center of an open cluster listed in the New Catalog of optically visible open clusters and candidates it would have been eliminated (Dias+, 2002). No pairs were eliminated.

Results

Table 1 provides a listing in the standard format of all the common proper motion pairs found. Table 2 provides detail of the proper motion of both components of each pair. It is somewhat surprising that these pairs have not been reported previously.

Conclusions

Each component of a common proper-motion pairs can be considered to be at the same distance from the observer, of the same age and subject to the same degree of reddening (Greaves, 2004). They are an interesting group to research because they do not fall into either of the extensively studied groups of orbiting binaries or open clusters.

Forty of the 51 pairs exhibit a catalogued V-J magnitude difference, a measure of the stars' color, of <1.0 but 8 pairs have a difference of >2.5. This diversity clearly has implications for any theory on the origin of such objects.

It is to be hoped that these new discoveries will be included in the Washington Double Star Catalog.

References

Greaves, J., 2004, "New northern hemisphere common proper-motion pairs", Mon. Not. R. Astron. Soc. 355, 585-590

Nicholson, M., 2005, "The Daventry Double Star Survey", J. Br. Astron. Assoc. 115, 338-342

(Continued on page 70)

Unreported High Proper Motion Northern Double Stars in the LSPM Catalog

Websites

Catalog of Northern stars with annual proper motions larger than 0.15", Lepine+ 2005
http://vizier.u-strasbg.fr/viz-bin/VizieR?source=I/298

The Washington Visual Double Star Catalog, 1996.0, Worley 1996
http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=I/237

#	RA J2000	DE J2000	Mag 1	Mag 2	PA (deg)	Sep. (as)	Date
1	00 10 56.07	+48 06 37.5	8.41	10.72	46.89	23.90	2000.000
2	00 40 06.26	+50 14 15.5	10.88	12.96	311.17	24.91	2000.000
3	01 41 51.50	+47 46 23.2	12.39	12.43	358.54	3.42	2000.000
4	02 48 40.72	+13 44 48.0	10.79	11.35	18.75	14.19	2000.000
5	03 02 09.83	+26 00 46.2	13.27	13.35	356.23	11.07	2000.000
6	03 27 52.36	+14 50 49.7	12.75	12.75	299.14	3.74	2000.000
7	03 30 28.34	+54 17 37.7	8.88	11.71	252.01	78.86	2000.000
8	03 44 48.90	+57 01 41.6	11.32	11.49	315.95	16.56	2000.000
9	04 07 57.53	+04 44 37.8	13.53	13.87	287.59	2.51	2000.000
10	04 10 38.31	+20 02 25.9	12.33	12.33	227.32	3.34	2000.000
11	04 12 48.86	+19 53 52.3	10.32	10.54	228.87	5.02	2000.000
12	04 45 25.41	+29 55 28.5	11.34	11.67	145.46	84.18	2000.000
13	06 20 53.28	+54 24 59.6	9.56	12.86	139.49	78.48	2000.000
14	07 26 40.04	+26 58 51.5	10.93	10.98	150.58	5.44	2000.000
15	07 31 36.14	+62 01 11.5	12.03	13.54	74.57	22.93	2000.000
16	07 47 27.92	+33 51 56.8	13.53	13.9	226.20	49.07	2000.000
17	07 48 07.48	+50 13 03.3	11.2	11.25	341.92	31.21	2000.000
18	08 15 33.20	+11 25 51.5	7.71	9.75	238.36	31.87	2000.000
19	08 21 26.46	+34 18 22.4	11.7	17.46	100.79	72.26	2000.000
20	08 26 45.45	+32 50 00.0	10.83	10.88	1.46	2.72	2000.000
21	08 45 53.45	+31 07 19.4	11.07	11.99	301.73	21.01	2000.000
22	08 52 58.17	+29 31 44.5	11.14	11.16	156.15	4.14	2000.000
23	08 57 42.11	+55 22 00.1	13.63	13.72	258.67	12.16	2000.000
24	10 38 40.78	+11 32 22.1	13.23	13.74	122.65	7.93	2000.000
25	11 22 44.74	+30 17 40.5	11.98	12.48	85.15	4.47	2000.000
26	11 32 23.31	+76 39 18.0	11.53	12.25	261.19	63.30	2000.000

Table 1: Listing of common proper motion pairs found in this study. *Continued on page 71.*

Unreported High Proper Motion Northern Double Stars in the LSPM Catalog

#	RA J2000	DE J2000	Mag 1	Mag 2	PA (deg)	Sep. (as)	Date
27	11 43 53.14	+33 18 30.6	13.4	13.4	222.74	3.38	2000.000
28	11 55 36.20	+73 30 19.1	12.59	12.66	150.88	3.33	2000.000
29	12 04 56.96	+17 28 35.9	8.66	13.4	206.53	27.21	2000.000
30	12 52 16.15	+38 35 40.0	13.8	13.9	158.38	10.61	2000.000
31	13 24 29.41	+41 12 00.8	11.07	11.6	172.57	8.31	2000.000
32	13 44 27.16	+77 13 50.9	9.45	13.63	291.29	66.57	2000.000
33	14 33 05.25	+55 27 33.7	9.62	11.71	333.60	28.93	2000.000
34	15 10 36.61	+39 23 12.7	13.01	13.3	53.92	8.30	2000.000
35	16 04 56.80	+39 09 23.4	6.66	12.86	280.36	70.28	2000.000
36	17 15 27.74	+30 52 36.6	11.33	13.6	166.20	15.03	2000.000
37	17 20 23.19	+20 16 57.4	9.83	13.83	124.15	4.50	2000.000
38	18 26 24.59	+11 20 57.4	13.09	13.09	190.35	7.80	2000.000
39	19 34 37.08	+50 39 11.3	11.22	11.33	50.69	28.81	2000.000
40	19 49 18.13	+41 34 56.9	7.53	10.47	67.05	66.84	2000.000
41	20 43 35.49	+45 14 10.7	12.98	13.58	165.83	17.69	2000.000
42	21 57 30.78	+28 56 13.4	8.76	13.98	189.31	85.01	2000.000
43	22 04 17.31	+09 51 34.6	11.53	13.44	135.47	40.44	2000.000
44	22 05 46.11	+65 38 50.7	10.53	11.65	315.74	6.75	2000.000
45	22 31 05.73	+45 08 42.4	7.69	13.74	7.66	62.21	2000.000
46	22 45 41.77	+41 12 10.5	9.04	10.79	323.13	21.08	2000.000
47	22 46 49.75	+19 01 01.0	9.01	13.05	89.68	25.55	2000.000
48	23 27 46.08	+12 23 40.9	12.54	13.77	278.68	11.61	2000.000
49	23 50 02.80	+05 30 46.0	9.62	10.87	124.78	11.18	2000.000
50	23 54 29.69	+29 38 17.7	8.51	12.55	201.94	22.49	2000.000
51	23 55 36.04	+00 41 45.0	9.23	13.6	253.20	12.97	2000.000

Table 1, cont.: Listing of common proper motion pairs found in this study.

Unreported High Proper Motion Northern Double Stars in the LSPM Catalog

#	PRIMARY pmRA arcsec/yr	SECONDARY pmRA arcsec/yr	PRIMARY pmDE arcsec/yr	SECONDARY pmDE arcsec/yr
1	0.169	0.168	0	0.003
2	0.146	0.143	-0.071	-0.073
3	0.256	0.209	-0.105	-0.108
4	0.115	0.114	-0.105	-0.104
5	0.161	0.161	-0.08	-0.08
6	0.172	0.172	-0.14	-0.14
7	0.147	0.125	-0.12	-0.13
8	0.113	0.116	-0.161	-0.158
9	0.166	0.166	-0.025	-0.025
10	0.045	0.045	-0.213	-0.213
11	0.247	0.241	-0.019	-0.028
12	0.001	0.002	-0.156	-0.16
13	-0.094	-0.092	-0.173	-0.159
14	-0.132	-0.139	-0.106	-0.105
15	0.025	0.025	-0.16	-0.16
16	0.179	0.124	-0.148	-0.096
17	-0.033	-0.035	-0.154	-0.154
18	-0.198	-0.198	-0.233	-0.23
19	-0.133	-0.111	-0.149	-0.116
20	0.034	0.039	-0.177	-0.184
21	0.002	0.025	-0.153	-0.16
22	0.083	0.084	-0.134	-0.144
23	0.164	0.164	0.065	0.065
24	-0.004	-0.004	-0.167	-0.167
25	0.146	0.146	-0.078	-0.078
26	0.115	-0.155	-0.6	-0.163
27	-0.215	-0.215	-0.081	-0.081
28	-0.224	-0.224	-0.08	-0.08
29	0.03	0.019	-0.209	-0.188
30	-0.084	-0.084	0.126	0.126

Table 2: Proper motion of each pair. Column 1 contains running numbers of the pairs, columns 2 and 3 contain proper motion data in right ascension taken directly from the catalog. Columns 4 and 5 contain proper motion data in declination taken directly from the catalog. *Continued on page 73.*

Unreported High Proper Motion Northern Double Stars in the LSPM Catalog

#	PRIMARY pmRA arcsec/yr	SECONDARY pmRA arcsec/yr	PRIMARY pmDE arcsec/yr	SECONDARY pmDE arcsec/yr
31	0.084	0.084	-0.141	-0.141
32	-0.165	0.026	-0.055	-0.181
33	-0.115	-0.098	-0.14	-0.133
34	-0.121	-0.136	0.099	-0.223
35	-0.572	-0.547	0.052	0.055
36	-0.182	-0.182	-0.171	-0.171
37	-0.053	-0.032	-0.176	-0.161
38	-0.014	-0.014	-0.266	-0.266
39	0.046	0.046	0.174	0.173
40	0.104	0.106	-0.176	-0.176
41	0.138	0.138	0.065	0.065
42	0.167	0.166	0.029	0.031
43	0.175	0.175	0.076	0.076
44	-0.312	-0.312	0.211	0.211
45	-0.174	-0.167	0.038	0.027
46	0.161	0.153	0.116	0.116
47	-0.064	-0.057	-0.176	-0.173
48	0.144	0.147	0.071	0.069
49	0.128	0.126	-0.097	-0.11
50	0.001	0.009	-0.192	-0.188
51	0.232	0.242	-0.002	-0.006

Table 2, cont.: Proper motion of each pair. Column 1 contains running numbers of the pairs, columns 2 and 3 contain proper motion data in right ascension taken directly from the catalog. Columns 4 and 5 contain proper motion data in declination taken directly from the catalog.

Martin Nicholson is a retired teacher who lives in Daventry, England. He has been a double star observer for 5 years and has contributed many measurements of previously neglected doubles to the Washington Double Star Catalog. He also makes photometric observations for the AAVSO.

Lambda Arietis = WDS 01579+2336

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Abstract: Measurements made of the double star Lambda Arietis with a CCD are compared with those made with a web-cam.

Lambda Arietis (λ Ari) is a pretty double star system for binoculars at 1h 57.9m +23°36' (2000.0). At a distance of 37 arcseconds from the 4.8 magnitude bright primary there is a companion of magnitude 6.7 (values taken from the WDS). This is definitely visible in steadily mounted 10x50 binoculars. Lambda Ari is catalogued in the Washington Double Star Catalog (WDS) under the discoverer designation of H 5 12 which is a code for William Herschel's distance class V, entry number 12 = H V 12. This double star was discovered before Herschel by Christian Mayer of Mannheim (Schlimmer, 2006).

Using a telescope, one can see two more faint wide companions: the WDS contains companion C with mag 9.7 at 188 arcsecond distance and D with mag 9.9 at 270 arcsecond distance. While looking at the system using my 130 mm refractor at 35x, it is obvious that companions C and D are not approximately equally bright, but C is about a magnitude fainter than D.

Lambda Arietis imaged by Peter Wienerroither, http://homepage.univie.ac.at/peter.wienerroither/pwafods/01579+2336.htm North is up and east to the left, as in a pair of binoculars. The letters identify the companions in the WDS.

Peter Wienerroither (2006) has a project underway of imaging wide double stars with his 106 mm refractor. He takes short exposures of 1 to 10 seconds with a CCD camera (SXV-H9) at a focal length of 1100 mm. He takes R(ed), G(reen) and (B)lue images and combines them to form color im-

Lambda Arietis = WDS 01579+2336

ages. On Peters images, companion C is clearly fainter than D. I measured his G(reen) images by differential photometry and got a magnitude difference between C and D of 1.5. The value is exact to around 0.1 mag and should be very near the visual magnitude difference. When looking up C in the Hubble Guide Star Catalog (GSC), I find a magnitude of 11.41 (these magnitudes are not very exact but usually in the right ballpark). D has an entry in the Tycho-2 catalogue and is given a V magnitude of 9.75 there. My measured magnitude difference is near this value.

I used Lambda Arietis as a test to compare Peter's CCD-images with my own Webcam Images. We use a very similar focal length of slightly more than one meter and Peter uses a 4-inch and I a 5-inch refractor. So I tried to take several Webcam videos. The resulting images are not as pretty as the CCD images and they do not reach to a magnitude limit as deep as the CCD due to the short exposure times possible with my off-the-shelf webcam (ToUCam Pro II). But the measures are almost exactly the same as the CCD measures! (See Table 1.) I trust the results even more since I used two different procedures to make them: the CCD images have a larger field of view and I did a classical astrometry with 6 reference stars from the Tycho-2 catalogue to determine the exact focal length and field orientation. Since the webcam has a much smaller field of view I used my own “drift astrometry” procedure: I let the stars drift across the field with the motor drive switched off and determine the field orientation this way. The focal length I calibrated with several dozen other observations. To reduce the images I use the software “Astronomical Image Processing” by Berry and Burnell in both cases. The only drawback of the cheap webcam was that I could not measure C due to its faintness.

components	webcam distance	webcam PA	CCD distance	CCD PA
A-B	37.4"	47.5°	37.5"	47.5°
A-C	---	---	188.7"	75.8°
A-D	270.7"	84.8°	270.5"	84.7°

Table 1: Comparison of measurements made with webcam to measurements made with CCD. PA = position angle. Webcam images taken at f = 1040 mm on 11 Jan 2006, CCD images taken at f = 1100mm on 14 Oct 2005. I am quite happy since the results agree so well!

The bright components A and B are apparently physically related: they show a common proper motion and did not change their distance and PA measurably in the more than 200 years since they have been measured for the first time. C and D seem to be unrelated stars showing a small or no proper motion so they change their distance to A over the years: see the following tables.

(Continued on page 76)

Date	Distance	PA	Source
1779	36.6″	48°	WDS as of Jan. 2006
2003	36.7″	47°	WDS as of Jan. 2006
2005.79	37.5″	47.5°	CCD measure

Lambda Ari A-B = H V 12AB

Date	Distance	PA	Source
1892	175.3″	74°	WDS as of Jan. 2006
1998	187.7″	76°	WDS as of Jan. 2006
2005.79	188.7″	75.8°	CCD measure

Lambda Ari A-C = H V 12AC

Date	Distance	PA	Source
1892	258.1″	84°	WDS as of Jan.2006
2001	269.6″	85°	WDS as of Jan.2006
2005.79	270.5″	84.7°	CCD measure

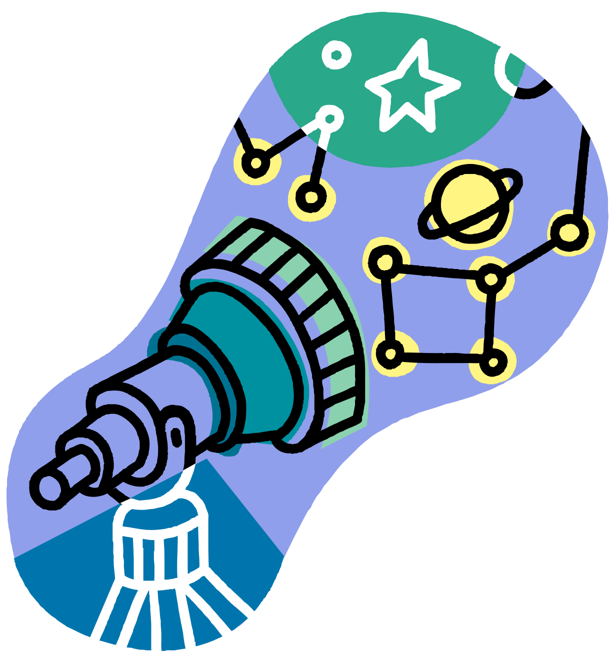
Lambda Ari A-D = H V 12AD

Lambda Arietis = WDS 01579+2336

References:

Schlimmer, 2006:
http://www.epsilon-lyrae.de/Doppelsterne/Galerie/GalerieDoppelsterne1.html#Aries
Wienerroither, 2006:
http://homepage.univie.ac.at/peter.wienerroither/pwafodse.htm
Double star astrometry with a webcam:
http://members.eunet.at/vollmann/ds/dsawc1e.htm
Hubble Space Telescope Guide Star Catalogue (GSC):
http://vizier.u-strasbg.fr/viz-bin/Cat?I/254
Tycho-2 Catalogue:
http://vizier.u-strasbg.fr/viz-bin/Cat?I/259
Washington Double Star Catalog (WDS):
http://ad.usno.navy.mil/proj/WDS/wds.html

Mr. Vollman tells us, "Mostly I admire beautiful and rare sights, naked eye or at the eyepiece of my telescope." Like so many of us, he became interested in astronomy as a child when being shown Orion. During the day he works as an IT instructor and lives in the suburbs of Vienna with his wife and two children.



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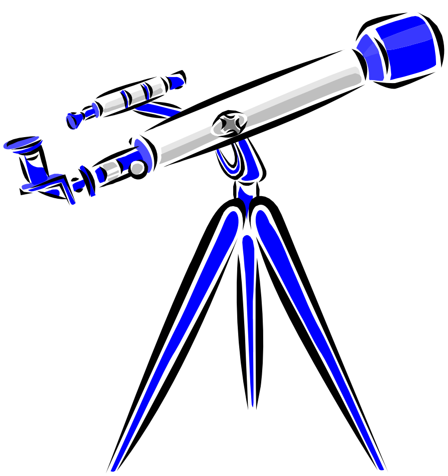
Questions, comments, or submissions may be directed to rkentclark@jaguar1.usouthal.edu or to rmollise@hotmail.com



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