

Double Star Measures for the Year 2004

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Abstract: This yearly report contains 77 measures, 6 of which are new discoveries. The instrumentation has remained unchanged over nearly two 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 about 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 Schöler Astro Imag-

ing and are made to Michael Bessel's formula as described in CCD Astronomy, Fall 1995. 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 arc seconds, 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: V= 0.36 N7. This simply means that the difference in magnitude in V-band is 0.36 and 7 CCD frames were analyzed to obtain a mean value. Often included is the number of measures and time in years since the last measure: 2m87. Additional photometry data is included throughout the notes section. Astrometry values are a minimum of 12 frame means.

Discoverer Designation	WDS α, δ 2000	Mags	θ (deg)	ρ (arcsec)	Date	n	Notes
GRB 34 AB	00184+4401	8.07 11.04	64.6	34.78	2004.997	1	R=2.86 N8
STF 296 AB	02442+4914	4.12 10.0	304.5	20.51	2004.003	1	Theta Per
STF 422	03368+0035	5.82 8.69	270.6	6.68	2004.063	2	

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Discoverer Designation	WDS α, δ 2000	Mags	θ (deg)	ρ (arcsec)	Date	n	Notes
STF 427	03406+2846	6.86 7.33	207.4	7.03	2004.090	1	
COU 364	03578+2255	8.78 11.12	146.5	2.40	2004.148	1	
STF 479 AB	04009+2312	6.52 7.47	126.7	7.44	2004.148	1	
STF 479 AC	04009+2312	6.6 9.0	241.6	57.79	2004.148	1	
STI 2051	04312+5858	12.7 12.7	62.2	9.24	2004.134	2	W D secondary, see last pg
STF 616	04593+3753	5.00 8.21	3.3	4.74	2004.153	1	V=3.18 N10, I=2.59N16
STF 649 AB	05083+0840	5.80 8.97	68.2	21.57	2004.129	1	
STF 668 A-BC	05145+0812	0.3 10.4	203.7	9.41	2004.129	1	Rigel
STT 545 AB	05597+3713	2.7 7.2	306.2	4.04	2004.162	1	Theta Aur.
SHJ 70 AB	06278+2047	6.65 8.18	202.6	25.17	2004.167	1	Optical
HJ 2319 AB	06340+4747	9.7 10.3	307.9	3.43	2004.241	1	4m78, note 1
HJ 2319 AC	06340+4747	9.2 (12.2)	262.2	14.61	2004.241	1	3m78
STF 946	06449+5927	7.30 9.11	129.4	4.03	2004.192	1	
STF 948 AB	06462+5927	5.44 6.00	73.5	1.88	2004.212	2	
STF 948 AC	06462+5927	5.44 7.05	308.5	8.74	2004.212	2	
HJ 417	07219+3442	9.0 11.6	70.3	18.24	2004.246	1	2m101, opening
BU 901 AB	07220+3646	5.13 11.7	9.5	11.52	2004.244	1	10m70, little change
DAL 16	07225+3554	(10.9 11.4)	323.0	30.53	2004.244	1	discovery note
STF 1110 AB	07346+3153	1.93 2.97	61.5	4.21	2004.230	1	Castor
STF 1245 AB	08358+0637	5.98 7.16	24.8	10.03	2004.268	1	V=1.27 N8, I=1.12 N9
A 2963	08415+0649	9.34 10.86	264.5	3.46	2004.274	1	8m11
STF 1273 AB- C	08468+0625	3.49 6.66	298.6	2.96	2004.290	1	Epsilon Hyd
STF 1273 AB- D	08468+0625	3.49 12.5	199.7	18.13	2004.293	1	
STF 1360 AB	09306+1036	8.86 8.95	242.5	13.89	2004.293	1	note 2
DAL 17	09369+0927	(10.4 12.8)	279.7	29.10	2004.304	1	discovery note

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Discoverer Designation	WDS α, δ 2000	Mags	θ (deg)	ρ (arcsec)	Date	n	Notes
STF 1547	11317+1422	6.33 9.14	330.6	15.43	2004.359	1	V=2.87 N9, I=2.24 N9
STF 1657	12351+1823	5.03 6.57	270.4	20.14	2004.383	1	V=1.63 N9, I=2.46 N8
STF 1692	12560+3819	2.85 5.52	229.0	19.34	2004.411	1	Cor Coroli, I=2.44 N10
STF 1702	12585+3817	8.67 9.28	82.3	35.86	2004.414	1	
STF 2161Aa-B	17237+3709	4.15 5.09	319.1	4.07	2004.653	1	
BRT 2434 AB	17299+2246	11.2 11.7	270.8	3.72	2004.647	1	
DAL 3 AC	17299+2246	11.2 (12.5)	262.7	64.4	2004.647	1	
COU 629	17432+2245	9.8 10.3	208.2	3.91	2004.647	1	
STF 2202 AB	17446+0235	6.16 6.17	93.1	20.57	2004.683	1	V=0.36 N7, I=0.45 N8
STF 2278 AB	18029+5626	7.62 7.79	28.2	35.94	2004.653	1	
STF 2278 AC	18029+5626	7.5 8.5	37.3	33.55	2004.653	1	
STF 2278 BC	18029+5626	7.62 8.16	145.7	6.00	2004.653	1	
STF 2282	18065+4022	7.40 8.00	82.9	2.53	2004.669	1	
BAL 1953	18083+0230	11.5 11.5	-----	-----	2004.675	1	Not Found
BAL 1954	18083+0209	9.8 11.5	226.8	13.70	2004.675	1	1m95, closing slightly
DAL 18 AB	18103+0209	(11.8 11.9)	271.8	12.43	2004.672	1	discovery note
DAL 18 AC	18103+0209	(11.8 12.4)	312.2	44.45	2004.672	1	
COU 204	18335+2102	9.3 9.8	129.4	10.08	2004.702	1	note3
STF 2398 AB	18428+5938	8.94 9.69	175.1	12.36	2004.642	1	Red Dwarf Binary, 11.6 ly
POU 3515	18443+2315	12.3 12.4	59.3	11.99	2004.683	1	note 4
STF 2406	18499+2626	7.12 11.21	4.5	4.83	2004.699	1	R=3.81 N1, I=3.34 N3
SHJ 282 AC	18549+3358	5.99 7.68	349.4	45.10	2004.721	1	
STI 2418	19111+5712	12.3 12.3	41.8	14.53	2004.669	1	note 5
ES 81	19265+4008	8.4 13.7	226.6	12.33	2004.732	1	2m87 PA incr, opening
HO 449	19265+2722	9.3 12.3	175.8	14.28	2004.732	1	3m96 PA decr, opening

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Discoverer Designation	WDS α, δ 2000	Mags	θ (deg)	ρ (arcsec)	Date	n	Notes
STF 2524	19266+2530	9.15 9.53	83.9	5.48	2004.727	1	V=0.36 N8, I=0.47 N4
ES 792	19267+5125	9.5 11.4	249.4	8.38	2004.738	1	1m95 PA decr, opening
ES 82	19267+4019	9.81 11.30	186.6	2.28	2004.766	2	6m13
STF 2540 AB	19333+2025	7.52 9.23	147.0	5.16	2004.729	1	V=1.67 N14, I=1.37 N15
DAL 20 AB	19346+5039	11.3811.45	50.2	28.98	2004.738	1	discovery note
DAL 20 AC	19346+5039	11.3812.39	112.1	84.5	2004.738	1	
DAL 19 AB	19352+5048	11.32 13.4	190.4	2.49	2004.760	1	discovery note
DAL 19 AC	19352+5048	11.32 12.9	38.1	9.05	2004.738	1	
STF 2671 AB	20184+5524	5.76 7.25	337.9	3.62	2004.817	1	V=1.24 N7, I=0.83 N12
STF 2727	20467+1607	4.36 5.14	266.2	9.08	2004.802	2	Gamma Del, R=1.06 N14
STF 2758 AB	21069+3845	5.20 6.05	150.7	30.91	2004.784	1	61 Cyg
KR 60 AB	22280+5742	9.93 11.41	70.5	2.36	2004.912	1	
STF 58 AC	22292+5825	4.21 6.11	191.4	40.61	2004.912	1	Delta Cep
STI 2803	22303+5752	(13.2 13.3)	117.1	10.16	2004.896	1	V=0.05 N4, R= - 0.35 N8
STT 473 AB	22303+5714	6.65 10.0	358.6	14.87	2004.885	1	V=4.03N11, I=3.60N10
DAL 21	22343+5716	(12.9 13.8)	306.3	7.12	2004.877	1	discovery note
STI 2826	22345+5717	(12.6 13.0)	353.1	7.72	2004.877	1	1m87, V=0.38 N1, I=0.50 N5
STF 2920 AB	22345+0413	7.55 9.02	143.4	13.54	2004.872	1	V=1.50 N12, I=1.16 N8
STF 2920 AC	22345+0413	7.55 (13.4)	60.7	16.20	2004.874	1	2m97, rectiline- arly closing
HJ 1796	22386+5648	5.21 10.8	6.4	31.80	2004.885	1	
STF 3049 AB	23590+5545	4.88 7.22	326.7	3.16	2004.962	1	
COU 1500	23592+4112	7.8 10.2	187.9	4.32	2004.975	1	1m33, Sep increas- ing
STF 3050 AB	23595+3343	6.54 6.75	333.5	2.02	2004.920	1	V=0.20 N3, I=0.19 N10
STI 3080	23596+5548	(12.7 12.7)	53.6	9.90	2004.953	1	note 6

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2004 - Notes

1) HJ 2319 AB & AC - Last measured in 1926, this difficult visual triple is measurable, with some difficulty, with a CCD. The A and B components are listed as magnitude 9.7 and 10.3, however, LSO V-band measures show the secondary rather fainter, however, the primary agrees well. Δm data for all components as follows: V-band AB = 1.49, AC = 3.42, I-band AB = 1.34, AC = 2.08. LSO Magnitudes are as follows: (V-band) A = 9.73, B = 11.22, C = 13.15, V-I A = 0.12, B = 0.27, C = 1.46. AB components do not appear to have a substantial color difference. A is listed as an A0. The C component appears to be a red star of spectral type K. The motion of the components is slight, AB widening with PA increasing and AC closing with PA increasing. On a few frames the C component hinted at duplicity with very roughly a separation of 0."5 and a PA of 244 degrees. It is shown as a non-star in Guide-8 so it could be double, but much too difficult to confirm at LSO. The motions are as follows: AB slight PA increase, Separation $\sim 0.4''$ increase, AC pa ~ 2 degree increase, Sep $\sim 0.3''$ decrease.

2) STF 1360 AB - Follow-up of last years measure where the secondary measured brighter than the primary. Hipparcos data indicates the secondary is variable between 8.72 and 9.24 and gives a nominal value for the primary magnitude as 8.84, well in agreement with LSO's 8.85. This year the critter was caught with the primary just slightly the brighter. LSO photometry as follows: Δm V-band = 0.01, I-band = 0.01, V-I primary = 1.08, secondary = 1.08.

3) COU 204 - Suspiciously in nearly the same location and with a nearly identical position angle as TOR 4, this pair caught my attention. The double was easily found, however, Tor 4 (Observatory of Torino) was not found even though it is listed just 1 arc minute north of COU 204. It appears that TOR 4 is simply a re-discovery of COU204. The proper motion of the primary is in PA ~ 305 , almost perfectly aligned with the pair's PA of 129.4. Assuming rectilinear motion, the COU separation of 6.6" (1967) and the TOR value of 7.4" (1976) predicts a 2004 separation of about 9.9", very close to the present 10.08", however, the Tycho 2 proper motion (62.4 MAS/yr total) predicts a separation of 8.9" for the same time period. Photometric data as follows: V magnitudes: primary = 10.00 N3, secondary = 11.37 N3. Δm V-band = 1.37, I-band = 1.39 N6. Similar color, very different magnitudes! It

appears this pair is an optical double.

4) POU 3515 - Last measured in 1951, (second measure) this double presents a few problems. First, the secondary is clearly brighter than the primary as listed in the WDS. Second, the motion in position angle for the 1951 measure shows an increase of 3 degrees from the discoverers first measure in 1905, however, the LSO measure presented here shows the angle decreasing by about 3 degrees from the original measure. The peak to peak deviation of the LSO p.a. measures of this pair is only 0.57 degrees, thus this pair is, with fair certainty, decreasing in p.a. The measure given here reverses the primary and secondary to reflect their brightness. Photometric Δm data as follows: V-band = 0.14, Unfiltered (\sim R-band) = 0.25, I-band = 0.45 A rough measure of color was made using LSO standard response factors as follows: Primary V-I=1.29, Secondary V-I=0.83. The primary, being the redder, might explain the original designation if blue plates were used in the determination. The separation measures indicate a slow widening.

5) STI 2418 - Last measured at discovery in 1917 this pair is listed as equal 12.3 magnitude objects. Stein used blue sensitive plates, thus it was no surprise to find this pair visually fainter. Guide 8 gives 12.9 mag for the secondary and 13.2 for the primary for a rough Δm of -0.30. This is in close agreement to LSO's unfiltered CCD Δm of -0.26 (a six frame average) Although, it is clear that the secondary is the brighter, the positions given here reflect Stein's original primary star. Some motion has occurred, with the separation increased by 0.3 arc seconds and PA decreased by about 2 degrees. The very similar colors raise the probability of true duplicity.

6) STI 3080- Last measured at discovery in 1917. An unfiltered, 4 frame average gives a delta m of -0.40 \pm 0.01. This is a 1.4 magnitude swing from the original blue plate measure so Stein's secondary is very red indeed. The measure reflects Stein's original designation for the primary. The following night 2004.956) photometry in V&I-bands was performed. The Δm results are as follows: V-band = 0.03, N15, I-band = -0.83 N6. Color indices: Primary: V-I = 0.58, Secondary: V-I = 1.44. V-band magnitudes: Primary = 12.74, Secondary 12.77. Another interesting item has emerged from this measure. It appears that the WDS position is a bit off as the pair is positioned (2000) at 23 hr 59 min 57.27 sec. + 55°48' 41".1 which leads to

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jumping the position from the listed 23596+5548 to 00000+5549.

2004 - Discoveries

DAL 16 (07h 22m 32.5728s +35°53' 33.021") A high cpm red pair. Δm measures as follows: V-band = 0.51, I-band = 0.63. LSO magnitudes: (V-band) Pri. = 10.89, Sec. = 11.40. LSO V-I values: Pri. = 1.96, Sec. = 1.83. Interesting that, on the face of it, the primary is slightly the redder. Photometry in the region of spectral class M tends to be a bit dicey!

DAL 17 (09h 36m 51.0495s +09°27'07.994") Found in the vicinity of ω Leonis after barely splitting same just for fun. This new double is a bit perplexing. The proper motion vector length is the same for both components (1.28' in one thousand years) with the primary in pa 258.7° and the secondary in pa 242.3°. LSO V-I values: Pri. = 0.83, Sec. = 0.82, Δm V-band = 2.37, I-band = 2.38. The distance to the primary is listed as 27.4 ly. Somehow the color of the secondary, being so similar to the secondary's color, is at odds with the primary's distance. At the listed distance the absolute magnitude and the visual magnitude are roughly the same, thus the primary's absolute magnitude of roughly 10.6 yields a Class M2-M3 red main sequence object. This leaves an interesting question regarding the nature of the secondary. Perhaps this is simply an optical pair.

DAL 18 AB & AC (18h 10m 19.52s +02°09'00.5") Found visually during an initial search for BAL 1954. Unfiltered CCD Δm as follows: AB = 0.07, AC = 0.57. Approximate equivalent R-band magnitude of primary is 11.8.

DAL 20 AB & AC (19h 34m 37.10s +50°39'12.18") Found visually while searching the region of ES 739. This double turns out to have a rather high common proper motion. Tycho values for proper motion are: RA = 46, dec=174 mas/yr for both components. The magnitudes appeared identical visually. The LSO magnitude measurements are those shown. LSO V-I values: A = 0.75, B = 0.78, C = 1.30. This shows the AB components to be nearly identical in color perhaps a mid G class and C reddish-orange, dropping it loosely into the K class. Δm measures as follows: V-band: AB = 0.07, AC = 1.01. I-band: AB = 0.04, AC = 0.46. All this indicates that A&B are physical.

DAL 19 AC (19h 35m 10.95s +50°48'26.29") An easy visual find stumbled upon while searching for ES 739. I believe this to be an unusual color contrast double. Tycho-2 data gives an extraordinary B-V value of 2.359, however, there is a measurement error of roughly ± 0.4 magnitude assigned. Even so, this places the primary at the red limit of spectral class M. Tycho data indicated no secondary so it measured a combined magnitude, thus small additional errors of color may exist. On the next clear moonless evening (2004.757) a photometry run was made with the following results: Δm B-band = 0.82, V-band = 1.63, I-band = 2.81, LSO Color Index: Primary B-V = 2.53, V-I = 2.41, Tertiary B-V = 1.72, V-I = 1.23. The LSO V-band magnitudes are shown in the tabulated results. The primary's B-V value is in close agreement with Tycho-2 data, supporting the measured deep redness.

DAL 19 AB- The difficult close pair AB was first noticed while setting-up the exposure for the above V-band photometry. Although, it showed on just a few of the 20-second exposure frames, it was pretty clear that it was not an image artifact. On 2004.760 the seeing was very good so an "all-out" attempt to confirm the discovery was made. It was decided to use 2x2 pixel binning to, in effect, half the focal length. This allowed a shorter (8 sec.) exposure, thus somewhat reducing seeing wander (See Figure 1). Now the suspected component showed in every V-band exposure and very delicately in some B-band images. An 8-frame average gave a V-band Δm of 2.04 showing the faint component to be 13.36 magnitude or about 0.4 magnitudes fainter than C. The overwhelming redness of the primary makes it virtually impossible for LSO to observe the close companion in R-band, let alone I-band!

DAL 21 (22h 34m 17.745s +57° 16' 13.04") Found by CCD in same frame with STI 2826. Δm results: V-band = 0.94 N1, I-band = 0.95 N4.

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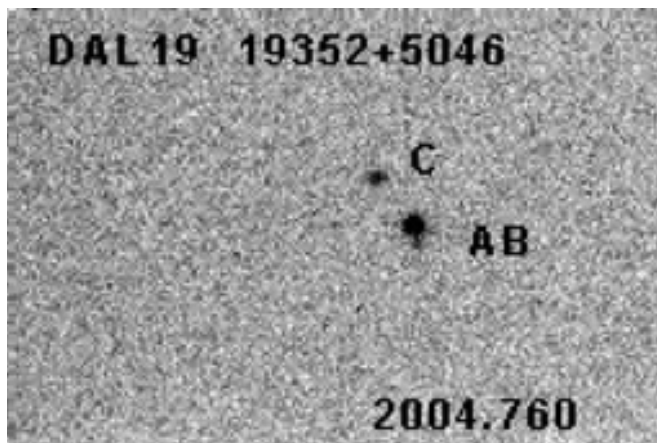


Figure 1 V-band , 8-sec Exp. The apparent duplicity of "C" is an image artifact.

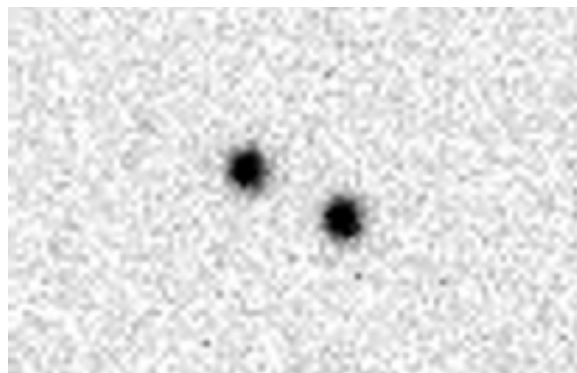


Figure 2: STI 2051 B-band. 100 sec exp. 2x2 Binning

LSO Photometric Data- STI 2051 (04315+5858)

Observation Date: February 10, 2004 (04.112)

Δm

B= 0.03, N=10 SIGMA= 0.02
 V=1.32, N= 6 SIGMA= 0.04
 R= 2.26, N= 6 SIGMA= 0.04
 I= 3.81, N= 6 SIGMA= 0.11

B-V

Primary = 1.65
 Secondary = 0.36

V-R

Primary = 1.26
 Secondary = 0.32

V-I

Primary =2.96
 Secondary = 0.47

Photometric Magnitudes

Primary: B=12.79, V= 11.14, R=9.88, I= 8.18
 Secondary: B= 12.82, V= 12.46, R= 12.14, I= 11.99

Position angle= 62.2° Separation= 9.24"

Figures 2 and 3 show CCD images of STI 2051 in the B and I bands, respectively.

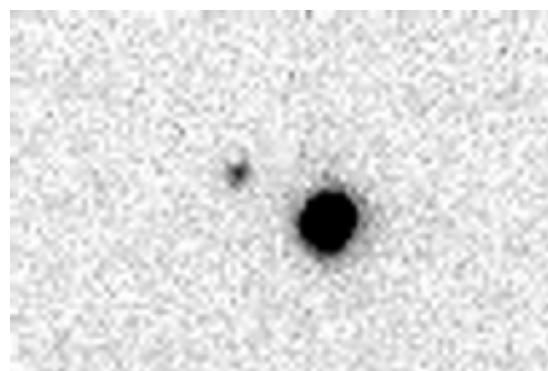


Figure 3: STI 2051 I-band 15 sec exp. 2x2 Binning