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Abstract: This report contains theta/rho measurements from 94 different double star systems. The time period spans from 2005.351 to 2005.479. 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.

Introduction

When one is interested in regularly making theta/rho measurements of double stars, which are known to be binary in nature, the thought may be that a large telescope, with expensive accessories, is a prerequisite for engaging in such efforts. While it is true that the majority of binaries, which have had orbital elements determined, might be out of reach for those who employ modest instrumentation, there are several binary systems that can be regularly monitored and measured with a small telescope. I am aware of at least four systems that have separations of over 10 seconds, which could be regularly studied. Additionally, there are another dozen or so that are within reach of a medium sized telescope. These binaries can be located in SKY CATALOGUE 2000.0, volume 2, in the visual binaries section. The four systems with 10+ seconds of separation are listed in Table 1 below for the convenience of the reader who might like to get started with this type of research program.

SKY CATALOGUE 2000.0 also provides an ephemeris for each listed system, so one can check on how well current measurements agree with the computed orbit. The systems mentioned above are all fairly bright, thereby enabling one to use an illuminated measuring device if that is desired.

Name	Coordinates	Theta	Rho	Year Measured
STF 60 AB	00491+5749	318 degrees	12.7 seconds	1999
STF 296 AB	02442+4914	308 degrees	20.5 seconds	1996
STF 1321 AB	09144+5241	92 degrees	17.3 seconds	1997
STF 275 AB	21069+3845	150 degrees	30.7 seconds	2000

Table 1: Four binary systems with separation over 10 arc seconds.

As in previous articles, the selected double star systems, which appear in this report, 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 stipulation include STF 2140 Aa-B and STF 2272 AB, 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.

As has been reported in previous articles, this one lists double stars that have displayed significant theta/rho shifts, because of the effects of proper motion, by one or both of the components. To begin with, WFC 310 has undergone a 5 % decrease in separation and an increase of 2 degrees in position angle, since 1970, because of proper motion by the reference point star. A large proper motion by the reference point star has also caused major theta/rho shifts for WFC 359. Since 1902, the separation has increased by 45” and the position angle has increased by 27 degrees. Both of these double stars have been neglected, and there is a great need for additional measurements by others.

An extremely large proper motion by the reference point star, in BUP 176, has caused theta/rho shifts of 7 degrees and 16 seconds since the last published measurements in 1984. In a like manner, a large proper motion shift by the "BC" components, in STN 41 A-BC, has caused theta/rho shifts of 14 degrees and 6.5 seconds since 1991. A proper motion shift is also noted for HLM 7 AB. Since 1983, the theta value has increased by almost 2 degrees, while the rho value has decreased by 2.7%. SMA 79 has also displayed a noteworthy proper motion shift. Since 1991, the rho value has decreased by 3% and the theta value has increased by 3 degrees.

An extended length of time, amounting to several decades since the last published catalog measurements, has contributed to detectable proper motion shifts in five additional double stars. As a consequence, ES 2664 has displayed a 3.3% decrease in the rho value since 1934. Similarly, HJ 2823 has shown a 4.1% decrease in the rho value since 1922. Also of note is the fact that the 1879 theta value for HJ 2823 matches the theta value listed in this report more closely than the value reported in 1922. The Hipparcos/Tycho data seems to confirm this finding. Thirdly, the rho value for STF 2057 AC has increased by 10" since the last published measurements in 1906. Fourthly, regarding BUP 177AC, the theta value has decreased by 4.5 degrees and the rho value has increased by over 7 seconds, since 1912. Finally, for HZG 13, a large proper motion by both components has caused a 29 degrees increase in the theta value and a 5" increase in the rho value, since 1946.

The fact that older measurements seem to reflect more accuracy than more recent measurements, in some cases, is relevant to the situation regarding Vat 2. For this double star, the 1916 measurements appear to match more closely with the measurements in this article, and with the Hipparcos/Tycho data, than do the measurements that were reported in 1941. If the 1916 measurements have a high degree of reliability, then this double star would appear to be a relatively fixed system.

Orbital motion may be the cause of theta/rho shifts in some common proper motion pairs that are listed in the table. STF 2128 might be one such pair, which has apparently displayed a large enough motion of this type that can be measured. Since 1995, the separation has increased by 4.4%. Likewise, orbital motion might have contributed to a 3 degrees decrease in the theta value for STF 2228, which also seems to be suggested by the Hipparcos/ Tycho data. However, the situation for STF 2228 needs further study because the last published catalog measurements were in 1905

Four additional double stars, bearing the "WFC" prefix, are in need of additional measurements because only a few theta/rho recordings currently exist. As a consequence, the theta/rho measurements for WFC 341 (18518-0505) vary by 6 degrees in p.a. and 1" in separation since the first measurements were made in 1892. There are no trends of increasing or decreasing values for either theta or rho because of the paucity of the data. The theta/rho values listed in the table match up fairly closely with those that are given in the Hipparcos/Tycho data for this common proper motion pair.

The lack of measurements has placed WFC 335 (18344+0853) is in a similar situation with WFC 341. In this case, the separation value has been recorded with a variance of 1.2" over the past several decades, with no obvious trend among prior measurements. The rho listing in the table does not match up closer than 5% with any other values in the WDS CATALOG or with Hipparcos/Tycho data. This double star is also a common proper motion pair.

Similarly, only a few theta/rho measurements exist for WFC 192 (12021+1521) and WFC 348 (19125+4447). As in the above cases, the theta/rho values show a random scattering with no apparent trends. Specifically, for WFC 192, the theta value has been recorded with a variance of 4 degrees, while the rho value for WFC 348 has been recorded with a 6.7% variance. These two double stars are also common proper motion pairs, and all four of these "WFC" pairs have been neglected for many decades.

I might also mention that there are discrepancies in how the WFC double stars are listed in the WDS CATALOG. The listings that are appearing in my reports have been taken from the 2001.0 web site catalog, but the USNO Double Star CD 2001.0 lists a different numerical sequence for the "WFC" doubles. To avoid confusion, the reader may wish to refer to these double stars with their coordinates.

Additionally, WFC 351 (19212-1146) and WFC 363 (19533+0820), which appear in this report, are not listed in the main catalog of the double star CD. This should probably be addressed because these double stars represent more neglected pairs that are in great need of additional measurements. The web site catalog lists only one previous set of measurements for both of these pairs, which were done in 1969 and 1957 respectively. For WFC 363, as an example, this article reports a 9 degrees increase in the theta value and a 4% decrease in the rho value since the 1957 measurements were published.

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Three measurement listings in the WDS catalog appear to be anomalous. In regards to BU 242 AD (17240-1142), the measurements for 1876 match fairly closely with the theta/rho values listed in this report, while the values for 1991 appear to be at a variance. Likewise, for SEI 696 AC (19508+3430), the measurements for 1894 closely match the measurements that were obtained for this report, while the listing for 1990 appears to deviate. Finally, the catalog measurements for HJ 1481 AB (20052+4923) are actually measurements for the "BC" components. The measurements listed in this report reflect the current parameters for the "AB" components.

NAME	RA DEC	MAGS	PA	SEP	DATE	N	NOTES
WFC 192	12021+1521	10.2 10.5	141.2	8.39	2005.386	1n	1
BEM 21	16030+5112	10.4 10.7	104.2	18.76	2005.425	1n	2
AG 201	16041+4858	10.4 10.6	252.4	7.90	2005.425	1n	3
AG 202	16056+4739	10.5 10.5	284.1	21.73	2005.425	1n	4
KU 110	16105+0354	10.2 10.6	271.3	61.23	2005.425	1n	5
MTL 1	16111-0814	10.2 10.6	350.2	37.52	2005.425	1n	6
RST3934 AB	16125-1359	10.2 10.6	179.7	29.63	2005.425	1n	7
ARG 75	16138-0147	10.4 10.7	64.0	21.73	2005.425	1n	8
SHJ 223 AC	16167+2909	5.8 10.4	20.8	86.90	2005.425	1n	9
SHJ 223 AD	16167+2909	5.8 10.2	50.9	123.44	2005.425	1n	9
STF2057 AC	16316+1917	10.4 10.3#	48.5	173.80	2005.427	1n	10
HLM 7 AB	16365+4856	10.3 10.6	7.8	25.68	2005.427	1n	11
HJ 4879 AC	16395-1744	10.4 10.6	78.3	34.56	2005.427	1n	12
BU 42	16401+2901	10.1 10.6	40.2	7.41	2005.441	1n	13
KU 114	16490+0315	10.5 10.4#	111.2	59.25	2005.441	1n	14
HEI 13	16534+2925	10.0 10.2	120.3	7.90	2005.441	1n	15
LDS 986	16569+2541	10.6 10.7	266.0	8.40	2005.441	1n	16
STF2178	17033+5935	8.6 10.0	44.0	12.84	2005.370	1n	17
WFC 305	17122+2137	9.9 10.6	301.0	6.91	2005.351	1n	18
BUP 176	17129+4220	10.1 9.8#	300.2	129.36	2005.425	1n	19
STF2140 Aa-B	17146+1423	3.3 5.3	104.6	4.94	2005.351	1n	20
STF2149	17200-0626	10.0 10.2	22.1	7.41	2005.427	1n	21
POP 218	17205+3439	10.4 10.4	89.0	30.61	2005.427	1n	22

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NAME	RA DEC	MAGS	PA	SEP	DATE	N	NOTES
BU 242 AD	17240-1142	8.6 10.4	61.7	47.40	2005.427	1n	23
WFC 310	17288+0020	5.4 9.6	315.8	47.40	2005.351	1n	24
STF2178	17295+3456	7.2 9.0	126.9	10.86	2005.351	1n	25
HJ 1300 A-BC*	17344+2520	10.5 10.7	256.9	13.33	2005.427	1n	26
WFC 314	17352+2545	9.8 10.4	102.7	7.90	2005.351	1n	27
BHA 58	17371-1636	9.9 10.3	140.1	23.70	2005.427	1n	28
ES 2660	17372+4309	10.1 10.1	154.2	8.89	2005.427	1n	29
ES 1257 AC	17383+4500	10.4 10.4	123.4	52.34	2005.427	1n	30
BUP 177 AC	17387+1834	9.5 9.7	268.6	374.26	2005.427	1n	31
SMA 79	17483+4506	10.4 10.7	89.9	15.31	2005.447	1n	32
STF2228	17492+0909	10.5 10.7	105.0	19.26	2005.447	1n	33
STF2227	17500+0520	10.3 10.7	110.3	15.31	2005.447	1n	34
HJ 855	17503+0415	10.1 10.4	79.8	19.75	2005.447	1n	35
LEO 14 AC	17519-0329	10.3 10.3	250.2	61.23	2005.447	1n	36
STT 160	17534+1058	8.4 9.6	191.1	101.71	2005.351	1n	37
HDO 147	17536-1726	10.5 10.7	205.1	12.34	2005.447	1n	38
POU3323	17549+2347	10.1 10.6	189.1	8.89	2005.447	1n	39
STF2278 AB	18029+5626	7.8 8.1	28.1	36.54	2005.370	1n	40
STF2278 AC	18029+5626	7.8 8.5	37.3	33.58	2005.370	1n	40
STF2278 AD	18029+5626	7.8 10.1	188.9	196.51	2005.370	1n	40
STT 164	18032+0755	8.1 9.2	359.7	50.36	2005.370	1n	41
STF2272 AB	18055+0230	4.1 6.2	137.1	4.94	2005.370	1n	42
STN 41 A-BC	18072-1854	9.7 10.2	214.7	27.65	2005.427	1n	43
STF2287 AB	18103+0235	10.4 10.7	152.5	22.71	2005.425	1n	44
VAT 2	18125-1852	9.2 9.8	85.5	7.41	2005.427	1n	45
ES 473 AB	18130+4251	10.1 10.4	98.7	30.61	2005.425	1n	46
HJ 2823	18150-1955	9.7 10.3	331.0	19.75	2005.427	1n	47
ES 2664	18157+3723	10.5 10.7	82.1	9.38	2005.425	1n	48

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NAME	RA DEC	MAGS	PA	SEP	DATE	N	NOTES
AG 220	18172+5103	10.3 10.3	126.9	10.86	2005.425	1n	49
SLE 162	18227+0614	10.3 10.6	141.9	20.74	2005.447	1n	50
SLE 184	18303+3246	9.3 10.5	63.4	35.55	2005.447	1n	51
ARA 283 AB	18326-1657	10.3 10.5	34.7	11.36	2005.449	1n	52
SLE 495	18329+0539	10.0 10.6	100.0	8.39	2005.449	1n	53
WFC 335	18344+0853	10.0 10.7	51.3	7.90	2005.370	1n	54
TAR 3 AB	18506+3313	10.5 10.7	304.5	14.81	2005.447	1n	55
WFC 341	18518-0505	9.6 9.6	307.9	8.89	2005.370	1n	56
GYL 13	19011+3210	9.9 10.3	305.2	34.07	2005.463	1n	57
ES 2237	19047+3334	10.2 10.6	219.3	9.88	2005.463	1n	58
HZG 13	19059+3502	9.7 10.2	134.4	26.17	2005.463	1n	59
STF2460	19080+1945	10.0 10.2	197.9	9.38	2005.463	1n	60
WFC 348	19125+4447	9.8 10.1	352.1	9.38	2005.389	1n	61
A 99 AC	19164-0925	10.0 10.2	78.5	46.41	2005.463	1n	62
HJ 2860	19174-1134	10.5 10.2#	110.2	21.23	2005.463	1n	63
WFC 349	19186+2038	10.1 10.3	71.5	8.89	2005.389	1n	64
WFC 351	19212-1146	10.5 10.6	60.9	9.88	2005.411	1n	65
ES 653	19261+5409	10.3 10.5	106.1	11.85	2005.463	1n	66
SEI 604	19286+3808	10.5 10.7	170.0	16.79	2005.463	1n	67
HJ 1409	19315+3107	10.0 10.5	358.3	14.32	2005.463	1n	68
ES 129 AC	19333+5249	9.9 10.3	273.2	72.09	2005.466	1n	69
SEI 644	19357+3309	10.0 10.3	159.4	16.79	2005.463	1n	70
ES 490 AB	19366+4327	10.1 10.1	222.5	64.19	2005.466	1n	71
STF 46	19418+5032	5.9 6.2	133.4	39.50	2005.389	1n	72
GUI 27 AC	19421+5319	10.3 10.4	113.4	82.95	2005.466	1n	73
SEI 669	19435+3433	10.3 10.5	47.4	16.79	2005.466	1n	74
WFC 359	19455+5046	9.0 10.7	214.5	53.33	2005.389	1n	75
STF2578 AB	19457+3605	6.4 7.0	125.0	14.81	2005.389	1n	76

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NAME	RA DEC	MAGS	PA	SEP	DATE	N	NOTES
STF2578 AF	19457+3605	6.4 9.0	249.7	145.16	2005.389	1n	76
HDS2811	19467-1129	10.1 10.1	201.0	16.29	2005.466	1n	77
AG 240	19501+4748	9.6 9.7	256.5	13.83	2005.466	1n	78
SEI 696 AC	19508+3430	10.2 10.0#	309.2	19.26	2005.466	1n	79
ES 2683	19517+5339	10.2 10.4	320.1	9.88	2005.466	1n	80
WFC 363	19533+0820	10.3 10.5	214.3	8.89	2005.479	1n	81
ARG 87	19535+4939	10.5 10.5	271.3	14.81	2005.466	1n	82
SMA 109	19538+4436	10.6 10.6	111.7	21.73	2005.466	1n	83
SEI 743	19572+3646	10.4 10.5	36.9	29.63	2005.466	1n	84
H 47 AB	20014+5006	5.1 8.8	149.5	41.48	2005.411	1n	85
HJ 1481 AB	20052+4923	10.4 10.6	59.8	34.07	2005.479	1n	86
HJ 1481 AC	20052+4923	10.4 10.7	92.3	27.65	2005.479	1n	86
HJ 1473	20054+2716	10.4 10.6	139.1	10.86	2005.479	1n	87
SEI 936	20097+3600	10.4 10.5	123.0	27.65	2005.466	1n	88
STF2648	20104+4949	8.1 9.5	116.3	6.91	2005.411	1n	89
SEI 958	20108+3646	10.0 10.0	323.4	21.23	2005.466	1n	90
SEI 962	20110+3642	9.1 10.7	289.4	23.21	2005.479	1n	91
HJ 1489 AD	20113+3550	9.7 9.9	50.5	17.28	2005.466	1n	92
HJ 1492 A-BC	20129+2913	10.2 10.5	53.9	18.27	2005.479	1n	93
STT 208	20349+4651	7.7 8.5	240.1	81.96	2005.411	1n	94

The companion star is the brighter component.
* Not listed this way in WDS CATALOG. “BC” too dim to clearly resolve.

<u>Notes</u>

1. In Coma Berenices. Common proper motion. Relatively fixed? Spect.. A5.
2. In Draco. Separation slightly increasing.
3. In Hercules. Relatively fixed. Common proper motion. Spect. G5.
4. In Hercules. Relatively fixed. Spect. F0, F0.
5. In Serpens. Sep. & p.a. slightly increasing. Spect. F8.
6. In Ophiuchus. Sep. & p.a. slightly increasing.
7. In Scorpius. Sep. decreasing; p.a. increasing. Spect. K0.

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8. In Serpens. Relatively fixed. Common proper motion. Spect. G0, G0.
9. Nu or 18 Coronae Borealis. AC & AD = sep. & p.a. dec. Spect. A3V, G, M8.
10. In Hercules. Separation increasing. Spect. K0.
11. In Hercules. Sep. decreasing; p.a. increasing. Spect. F0, F0.
12. In Ophiuchus. Sep. decreasing; p.a. increasing. Spect. A8IV.
13. In Hercules. Sep. & p.a. increasing. Spect. G0, G.
14. In Ophiuchus. Sep. & p.a. slightly increasing. Spect. F2.
15. In Hercules. Common proper motion; p.a. decreasing. Spect. G0, G0.
16. In Hercules. Relatively fixed. Common proper motion.
17. In Draco. Common proper motion; sep. inc. Spect. K4V, K0.
18. In Hercules. Relatively fixed. Common proper motion.
19. In Hercules. Sep. decreasing; p.a. increasing. Spect. M1V, K2.
20. Alpha or 64 Herculis. Position angle decreasing. Spect. M5I, M5II.
21. In Ophiuchus. Relatively fixed. Spect. G0.
22. In Hercules. Relatively fixed. Common proper motion. Spect. F8, F8.
23. In Serpens. Position angle slightly decreasing. Spect. A2.
24. In Ophiuchus. Sep. decreasing; p.a. increasing. Spect. A5, G5.
25. In Hercules. Position angle slightly decreasing. Spect. K0, K0.
26. In Hercules. Slight sep. increase and p.a. decrease.
27. In Hercules. Separation slightly increasing. Spect. G5, G5.
28. In Ophiuchus. Sep. decreasing; p.a. increasing. Spect. B9V, A1V.
29. In Hercules. Common proper motion; p.a. increasing. Spect. G, G.
30. In Hercules. Separation decreasing. Position angle increasing.
31. In Hercules. Sep. increasing; p.a. decreasing. Spect. K5, F5.
32. In Hercules. Sep. decreasing; p.a. increasing.
33. In Ophiuchus. Common proper motion; p.a. poss. decreasing. Spect. F8, G0.
34. In Ophiuchus. Sep. & p.a. decreasing. Spect. K5.
35. In Ophiuchus. Sep. increasing; p.a. decreasing. Spect. K2.
36. In Ophiuchus. Relatively fixed.
37. In Ophiuchus. Relatively fixed. Spect. B8, A0.
38. In Sagittarius. Relatively fixed. Common proper motion. Spect. B8.
39. In Hercules. Relatively fixed. Common proper motion. Spect. F0.
40. In Draco. AB = cpm; p.a. inc. AC = p.a. inc. Spect. A9V, A0, A0, G0.
41. In Ophiuchus. Position angle decreasing. Spect. K0.
42. 70 Ophiuchi. Sep. inc.; p.a. dec. Spect. K0V, K4V.
43. In Sagittarius. Sep. increasing; p.a. decreasing. Spect. K2/K3III.
44. In Ophiuchus. Sep. & p.a. slightly increasing.
45. In Sagittarius. Relatively fixed versus 1916 measurements. Spect. A2V.
46. In Hercules. Sep. & p.a. slightly decreasing. Spect. F2, F2.
47. In Sagittarius. Separation decreasing. Spect. B1III.
48. In Lyra. Sep. decreasing; p.a. increasing.
49. In Draco. Common proper motion. Sep. & p.a. decreasing. Spect. F8, F8.
50. In Serpens. Relatively fixed.
51. In Lyra. Sep. increasing; p.a. decreasing. Spect. K0, F2.
52. In Sagittarius & NGC 6645. Sep. increasing; p.a. decreasing.
53. In Serpens. Relatively fixed. Common proper motion. Spect. G0, G0.
54. In Ophiuchus. Common proper motion.
55. In Lyra. Sep. & p.a. increasing.
56. In Scutum. Common proper motion. Spect. G0, G0.
57. In Lyra. Separation increasing.

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58. In Lyra. Sep. increasing; p.a. decreasing.
59. In Lyra. Sep. & p.a. increasing.
60. In Sagitta Relatively fixed. Spect. A0.
61. In Lyra. Common proper motion. Relatively fixed? Spect. F8, F8.
62. In Aquila. Sep. increasing; p.a. decreasing.
63. In Aquila. Sep. & p.a. increasing. Spect. G0, G0.
64. In Sagitta. Relatively fixed. Common proper motion. Spect. F8, F8.
65. In Aquila. Sep. & p.a. decreasing. Spect. A2. Only 1 catalog meas. in 1969.
66. In Cygnus. Relatively fixed. Common proper motion.
67. In Cygnus. Common proper motion. Separation decreasing.
68. In Cygnus. Separation increasing.
69. In Cygnus. Sep. slightly increasing. Spect. G0, G0.
70. In Cygnus. Relatively fixed.
71. In Cygnus. Separation slightly increasing.
72. In Cygnus. Relatively fixed. Common proper motion. Spect. G1.5V, G0.
73. In Cygnus. Separation slightly decreasing.
74. In Cygnus. Position angle slightly decreasing. Spect. A3.
75. In Cygnus. Sep. & p.a. increasing. Spect. G5.
76. In Cygnus. AB = cpm; relfix. AF = sep. inc. Spect. B9.5V, A0, K8.
77. In Aquila. Relatively fixed. Common proper motion. Spect. F8, F8.
78. In Cygnus. Relatively fixed. Common proper motion. Spect. A2, A2.
79. In Cygnus. Relatively fixed. Common proper motion.
80. In Cygnus. Relatively fixed. Common proper motion.
81. In Aquila. Sep. decreasing; p.a. increasing. Spect. F0.
82. In Cygnus. Relatively fixed. Common proper motion. Spect. F8, F8.
83. In Cygnus. Sep. increasing; p.a. decreasing. Spect. A.
84. In Cygnus. Relatively fixed.
85. 26 Cygni. Position angle increasing. Spect. K1II.
86. In Cygnus. AB = p.a. decreasing. AC = p.a. increasing. Spect. K2III.
87. In Vulpecula. Relatively fixed. Common proper motion. Spect. G0.
88. In Cygnus. Relatively fixed. Spect. B, A0.
89. In Cygnus. Relatively fixed. Common proper motion. Spect. F5, F5.
90. In Cygnus. Slight p.a. decrease. Spect. B8IV.
91. In Cygnus. Sep. increasing; p.a. decreasing. Spect. K1III, K1III.
92. In Cygnus. Relatively fixed. Spect. B2III, B2.
93. In Vulpecula. Sep. increasing; p.a. decreasing. Spect. A2, A2.
94. In Cygnus. Separation increasing. Spect. K0, A0.