Divinus Lux Observatory Bulletin: Report #11

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Abstract: This report contains theta/rho measurements from 93 different double star systems. The time period spans from 2007.282 to 2007.518. 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.

A few years ago, when I was writing articles for publication in the *Double Star Observer*, I submitted two reports dealing with statistical studies that I had made regarding the nature of double star systems. The data used in these studies came from catalogs that were available at the time. Because this type of work has always been of interest to me, I was especially drawn to some similar research that was reported by Charles Lada, from the Harvard-Smithsonian Center for Astrophysics, in early 2006.

In his article, "Stellar Multiplicity and the IMF: Most Stars are Single," published in the *Astrophysical Journal Letters*, Dr. Lada suggests that there exists a low binary star fraction for late type stars. In essence, stars of spectral type M, L, and T are far less likely to be binary in nature than are O, B, A, F, and G stars, indicating that there could be a relationship between spectral type and the percentage of stars that are single. The studies that Lada refer to indicate that 43% of G stars are single, while the percentage jumps to 74% for M stars. The percentages appear to be even higher as one moves to the right on the scale towards L and T stars. Because late type stars are far more numerous in the main sequence, Lada concludes that two thirds of all main sequence primary stars, which currently reside in the galactic disk, are single stars.

Therefore, Lada's paper seems to challenge earlier articles on this subject which, for example, suggested a binary frequency rate of as much as 70 – 80% for F and G stars. While some of the research that Lada cites in his report is, admittedly, uncertain because of small sample size, studies utilizing the results of volume complete searches within a few parsecs of the Sun are also referenced. Perhaps previous conclusions regarding the frequency of binary systems will now need to be reexamined. For those who would like to study Lada's article in depth, it may be accessed from his personal website. I have chosen to give this brief summary of Lada's work, in my article, for the benefit of the reader who may also have an interest in this subject, but who may have been unaware of this recent research.

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. Beginning with this report, additional systems have also been selected from the 2006.5 W.D.S. Catalog. There are also some noteworthy items that are discussed pertaining to the following table.

First of all, several double stars are being mentioned for having significant theta/rho shifts because of proper motion from one or both of the components. In this regard, H 90 is a noteworthy example. Because of a large proper motion by the reference point star, the rho value, for this system, has increased by 23" since 1991. Proper motion by the reference point star, for SLE 687 AB-E, is also responsible for a rho value increase of 3.3" and a theta value increase of 4.9

degrees since 1991. Proper motion by the companion star, in regards to SKF 10, is the cause for 6.3 degrees decrease in the theta value and a 9% decrease in the rho value since 1981.

In addition, ENG 60 Aa-B has shown an increase of 8.4 degrees in the theta value and a decrease of 9.4" in the rho value since 1910. Proper motion by "Aa," relative to "B," plus the passage of almost 100 years since the last published measurements are responsible for these large shifts. Proper motions by both components, for SLE 4, have caused a huge increase in the theta value, amounting to about 63.7 degrees. since 1982. During the same time period, the rho value has decreased by almost 8".0.

Regarding STF 2523 AC, a theta value of 146.9 degrees is being reported, which does not appear to be supported by the WDS or the Hipparcos/Tycho Catalogs. While a value of 144 degrees is commonly listed, I was not able to obtain such a measurement even after recalibration of the micrometer. The theta parameter for this system probably needs additional measurements from others in order to determine which value is more accurate.

Also worthy of mention are the measurements that are being reported for the visual binary star STF 2021 Aa-B. While the orbit for this binary is listed as "grade 5" in the visual binary stars section of Sky Catalog 2000.0, the theta/rho measurements appearing in the table match up well with those that are generated using the orbital elements that are currently recorded for this system. In addition, both sets of these theta/rho values agree closely with the values listed in the WDS Catalog.

Another double star, STF 2727, also appears to have displayed theta/rho shifts because of orbital motion. While not listed as a visual binary in Sky Catalog 2000.0, this common proper motion pair has displayed decreases of 2 degrees in the theta value and 3% in the rho value since 1997. This pair is also known as Gamma or 12 Delphinus.

As has appeared in previous reports, this one contains listings for possible common proper motion pairs, bearing the ARN prefix, which do not appear to have been previously recorded. The first one, ARN 95 (18516-0724), is located in Scutum near STF 2405. The theta/rho values are 105.5 degrees and 30.12 arc seconds. Secondly, a "C" component has been added to A 281 (20106+3452), labeled as ARN 96 AC. With theta/rho measurements of 313.5 degrees and 63.69 arc seconds, this star appears to share a common proper motion with the "AB" components. Finally, ARN 97 (20171+4127) is located in Cygnus near ES 1674. The theta/rho values for this possible common proper motion pair are 219.9 degrees and 12.84 arc seconds.

A possible correction is being noted for the WDS Catalog. In regards to HJ 1431 AC, the Catalog coordinates are listed as 19412+4126, but the current location of this double star appears more closely to 19406+4129. If other researchers had difficulty locating this pair, as a result, this might explain why the last published measurements were in 1912, with only one set of measurements being reported. The "B" component, which was last measured in 1914, appears to be entirely absent from current star charts.

NAME	RA DEC	MAGS	PA	SEP	DATE	N	NOTES
H 90	13184-1819	4.7 10.7	36.9	376.24	2007.282	1n	1
STF1764 AB	13377+0223	6.7 8.5	30.9	15.80	2007.282	1n	2
STF1764 AC	13377+0223	6.7 10.4	139.3	171.83	2007.282	1n	2
STF1795	13589+5306	6.9 9.8	2.4	7.90	2007.282	1n	3
STF1803	14064+3825	8.0 10.3	42.6	17.78	2007.282	1n	4
STF1804	14083+2112	8.1 9.2	13.8	4.94	2007.282	1n	5
STF1843 AB	14246+4750	7.6 9.2	186.5	19.75	2007.282	1n	6
STF1843 AC	14246+4750	7.6 9.7	63.7	98.75	2007.282	1n	6
STF1910	15075+0914	7.3 7.5	212.1	3.95	2007.351	1n	7

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NAME	RA DEC	MAGS	PA	SEP	DATE	N	NOTES
SKF 10	15111+4424	10.1 10.7	284.7	13.83	2007.351	1n	8
STF1934 AB	15174+4348	9.3 9.5	13.7	9.38	2007.301	1n	9
STF1942	15261+2128	9.4 10.6	91.7	9.88	2007.301	1n	10
STF1950	15300+2530	7.9 9.1	93.3	3.46	2007.301	1n	11
STF1973	15464+3627	7.6 8.7	320.9	30.61	2007.351	1n	12
STF1990 AB	15589+2147	8.5 9.2	62.1	55.79	2007.301	1n	13
STF1990 AC	15589+2147	8.5 9.3	59.8	59.25	2007.301	1n	13
STF1990 BC	15589+2147	9.2 9.3	26.5	3.95	2007.301	1n	13
STF2021 Aa-B	16133+1332	7.3 7.4	355.6	4.44	2007.351	1n	14
BU 815 AD	16271+4255	8.7 9.8	86.1	435.49	2007.301	1n	15
BUP 170 Aa-B	16302+2129	2.8 10.6	274.7	245.89	2007.301	1n	16
STF2063	16318+4536	5.7 8.6	195.8	16.29	2007.351	1n	17
STF2078 AB	16362+5255	5.4 6.4	106.0	2.96	2007.351	1n	18
STF 30 AC	16362+5255	5.4 5.5	192.8	89.37	2007.351	1n	18
STF2080 AD	16386+3820	8.8 7.4*	80.3	397.96	2007.301	1n	19
STF2079	16396+2300	7.5 8.1	90.5	16.79	2007.351	1n	20
SLE 687 AB-E	16555-0820	9.0 10.2	323.9	295.26	2007.351	1n	21
SLE 4	17003+1958	10.7 10.7	281.7	11.85	2007.477	1n	22
FOX 281 AC	17047+1936	6.2 10.3	133.1	106.65	2007.400	1n	23
ENG 60 Aa-B	17200-0801	7.9 10.5	231.4	90.85	2007.477	1n	24
STT 329 AB	17245+3657	6.3 9.8	13.1	33.08	2007.397	1n	25
STF2181 AB	17317+3019	6.9 10.5	326.4	32.59	2007.397	1n	26
STF2186	17358+0100	8.2 8.4	79.4	2.96	2007.400	1n	27
STF2213	17449+3108	8.1 8.9	327.8	4.94	2007.397	1n	28
STF2225 AC	17452+5157	8.9 10.1	244.5	229.10	2007.397	1n	29
STF2225 CD	17452+5157	10.1 10.5	298.3	8.89	2007.397	1n	29
STF2252 AB	17590+0202	8.6 8.9	23.5	3.95	2007.400	1n	30
STF2252 AC	17590+0202	8.6 8.9	164.5	94.80	2007.400	1n	30
STF2271 AB	18003+5251	8.1 9.2	268.6	3.46	2007.400	1n	31
STF2265	18041+0628	9.8 10.5	281.7	23.70	2007.400	1n	32
STF2279	18046+5053	9.8 10.2	180.0	13.33	2007.400	1n	33
STT 346	18154+1946	8.3 9.0	329.5	5.43	2007.400	1n	34
STF2316 Aa-B	18272+0012	5.3 7.6	319.1	3.95	2007.400	1n	35

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NAME	RA DEC	MAGS	PA	SEP	DATE	N	NOTES
STF2333 AB	18311+3215	7.8 8.6	333.3	6.42	2007.400	1n	36
STF2329	18314+0628	8.2 9.4	43.0	4.44	2007.477	1n	37
STF2362	18384+3603	7.5 8.7	189.5	3.95	2007.400	1n	38
H 37 Aa-C	18426+5532	5.0 8.1	340.4	330.81	2007.400	1n	39
STF2398 AB	18428+5938	8.9 9.8	175.1	12.34	2007.479	1n	40
STF2373	18459-1030	7.3 8.3	336.9	4.44	2007.400	1n	41
ARN 95**	18516-0724	10.2 10.7	105.5	30.12	2007.477	1n	42
STF2405 AC	18521-0716	8.0 10.7	302.5	25.18	2007.477	1n	43
STF2417 AB	18562+0412	4.6 4.9	104.2	22.71	2007.477	1n	44
STF2417 AC	18562+0412	4.6 6.7	59.5	421.66	2007.477	1n	44
ENG 66 Aa-B	19080+1651	6.1 10.7	287.8	132.33	2007.455	1n	45
STF2470	19088+3446	7.1 8.4	268.5	13.83	2007.477	1n	46
STF2474Aa-B	19091+3436	6.7 7.8	263.1	15.80	2007.477	1n	47
STF2480	19118+2615	7.7 10.1	22.8	15.31	2007.455	1n	48
STF2486 AB	19121+4951	6.5 6.6	206.4	7.41	2007.477	1n	49
HJ 1380	19127+4746	9.4 9.9	226.2	5.43	2007.455	1n	50
STT 371 AB-C	19159+2727	7.1 9.7	270.5	47.40	2007.479	1n	51
H 48	19264+0149	8.1 10.6	172.9	152.08	2007.455	1n	52
STF2524	19266+2530	9.1 9.5	83.9	5.43	2007.455	1n	53
STF2523 AB	19268+2110	8.0 8.0	147.7	6.42	2007.479	1n	54
STF2523 AC	19268+2110	8.0 7.2*	146.9	250.83	2007.479	1n	54
HU 1194 AC	19281+3521	9.8 10.7	207.6	29.13	2007.455	1n	55
BLL 40	19368+5012	10.3 9.9*	13.4	91.34	2007.455	1n	56
STF2551 AB	19374+2249	9.6 10.5	41.3	6.91	2007.455	1n	57
STF2552	19379+1922	8.5 9.1	195.0	5.43	2007.455	1n	58
HJ 1431 AC	19406+4129	10.6 10.6	157.7	13.83	2007.455	1n	59
SEI 696 AC	19508+3430	10.2 10.0*	309.3	19.26	2007.455	1n	60
STT 388 AB	19524+2551	8.3 8.5	138.0	3.95	2007.479	1n	61
STT 388 AC	19524+2551	8.3 9.5	129.5	31.60	2007.479	1n	61
STF2589	19525+0039	8.5 8.8	294.2	4.94	2007.455	1n	62
ES 1970 AB	19591+3942	9.9 10.4	149.5	17.78	2007.455	1n	63
SCJ 24	19596+1153	9.0 10.6	6.5	38.51	2007.455	1n	64
HJ 1468	20015+4018	7.9 10.3	281.5	11.85	2007.482	1n	65

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NAME	RA DEC	MAGS	PA	SEP	DATE	N	NOTES
HJ 2918	20019-1733	8.0 8.3	134.8	15.80	2007.518	1n	66
STF2639 AB	20093+3529	7.8 8.7	301.8	5.93	2007.482	1n	67
TOB 50	20105+3323	9.0 10.1	268.9	31.60	2007.482	1n	68
A 281	20106+3452	9.0 9.4	173.0	4.44	2007.518	1n	69
ARN 96 AC**	20106+3452	9.0 9.7	313.5	63.69	2007.518	1n	69
STT 203	20131+3411	8.3 9.1	37.0	88.88	2007.482	1n	70
STT2663	20168+3942	8.2 8.7	321.8	5.43	2007.518	1n	71
ARN 97**	20171+4127	9.9 10.6	219.9	12.84	2007.518	1n	72
STF2671 AB	20184+5524	6.0 7.5	338.0	3.95	2007.518	1n	73
STT 205	20197+4108	7.2 8.9	320.0	45.43	2007.482	1n	74
STT 206 AB	20230+3913	6.7 8.5	254.7	43.45	2007.518	1n	75
AG 404	20241+2823	9.9 10.7	247.4	34.07	2007.482	1n	76
SEI1160 AB	20327+3916	8.2 10.3	49.9	14.32	2007.482	1n	77
HJ 2987	20410+2001	10.5 10.7	115.9	10.86	2007.518	1n	78
STF2715	20418+1231	7.8 10.1	2.0	12.34	2007.482	1n	79
HJ 1565	20433+2300	8.7 9.0	66.8	16.79	2007.482	1n	80
STF2725	20462+1554	7.5 8.1	11.2	6.42	2007.518	1n	81
STF2727	20467+1607	4.2 5.0	266.1	8.89	2007.518	1n	82
STF2728 AB	20482+2624	7.7 10.3	24.2	9.88	2007.482	1n	83
STF2742	21022+0711	7.4 7.6	215.5	2.96	2007.499	1n	84
STF2747	21024+3739	8.4 8.6	266.2	4.44	2007.518	1n	85
ES 2704 AB	21036+5358	8.5 8.9	96.8	54.31	2007.499	1n	86
STF2762 AC	21086+3012	5.7 10.1	229.3	59.25	2007.518	1n	87
ES 1453	21100+4326	8.9 9.9	68.4	5.43	2007.499	1n	88
AG 270	21189+3909	9.2 10.2	111.8	5.93	2007.499	1n	89
COU 132	21220+2350	8.8 10.3	201.4	13.33	2007.499	1n	90
STF2802	21318+3349	8.6 8.7	9.0	3.95	2007.518	1n	91
BLL 55 Aa-B	21432+3801	7.9 10.7	116.9	142.20	2007.499	1n	92
STF2848	21580+0556	7.2 7.7	56.9	10.86	2007.518	1n	93

* Companion star is the brighter component.
** Not listed in the WDS CATALOG.

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Notes

1. 61 Virginis. Separation increasing. Spect. G6V.
2. In Virgo. AB & AC = relatively fixed. Spect. K2III.
3. In Ursa Major. Relatively fixed. Spect. A2, A2.
4. In Canes Venatici. Position angle decreasing. Spect. K0.
5. In Bootes. Common proper motion; p.a. decreasing. Spect. F8, F8.
6. In Bootes. AB = relfix; cpm. AC = sep inc; p.a. dec. Spect. F4V, F5, G5.
7. In Bootes. Common proper motion; p.a. increasing. Spect. G2V, G3V.
8. In Bootes. Sep. & p.a. decreasing. Spect. K4, K.
9. In Bootes. Sep. increasing; p.a. decreasing. Spect. G5, G5.
10. In Serpens. Relatively fixed. Common proper motion. Spect. G5, G5.
11. In Serpens. Separation increasing. Spect. K4III, K4III.
12. In Corona Borealis. Common proper motion; p.a. slightly dec. Spect. F5, G0.
13. In Serpens. AB & AC = sep. dec. BC = relfix; cpm. Spect. K2, A2, A2.
14. In Hercules. Sep. & p.a. increasing; cpm. Spect. G8V, G8V.
15. In Hercules. Separation decreasing. Spect. G5, K0.
16. Beta or 27 Herculis. Separation decreasing. Spect. G7III.
17. In Hercules. Relatively fixed. Common proper motion. Spect. A2V, A0.
18. 17 Draconis. AB & AC = sep. & p.a. dec.; cpm. Spect. B9V, B9V, B9.5V.
19. In Hercules. Separation slightly decreasing. Spect. K0, A2.
20. In Hercules. Relatively fixed. Common proper motion. Spect. F0, A5.
21. In Ophiuchus. Sep. & p.a. increasing. Spect. M3V.
22. In Hercules. Sep. decreasing; p.a. increasing.
23. In Hercules. Separation slightly decreasing. Spect. A0IV.
24. In Ophiuchus. Sep. decreasing; p.a. increasing. Spect. G2V.
25. In Hercules. Relatively fixed. Spect. G5III, F0V.
26. In Hercules. Sep. & p.a. increasing. Spect. K0.
27. In Ophiuchus. Common proper motion; p.a. decreasing. Spect. B8IV, B8.
28. In Hercules. Common proper motion; p.a. decreasing. Spect. F8, F8.
29. In Draco. AC = relfix. CD = sep. & p.a. decreasing. Spect. K2, G5, K8.
30. In Ophiuchus. AB & AC = relatively fixed. Spect. A2, A2, K.
31. In Draco. Common proper motion; sep. & p.a. increasing. Spect. G0, G0.
32. In Ophiuchus. Sep. & p.a. slightly decreasing. Spect. G5III, F0.
33. In Draco. Common proper motion; p.a. decreasing. Spect. F8.
34. In Hercules. Relatively fixed. Common proper motion. Spect. F2, F2.
35. 59 Serpentis. Common proper motion; p.a. increasing. Spect. G0III, G0III.
36. In Lyra. Common proper motion; p.a. slightly decreasing. Spect. B9IV, A0.
37. In Ophiuchus. Relatively fixed. Common proper motion. Spect. B9IV, B9V.
38. In Lyra. Common proper motion; p.a. increasing. Spect. A5, A5.

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39. 46 Draconis. Sep. & p.a. slightly decreasing. Spect. B9.5, K0.
40. In Draco. Common proper motion; p.a. increasing. Spect. M4, M5.
41. In Scutum. Common proper motion; p.a. decreasing. Spect. F2, F2.
42. In Scutum. Common proper motion. Near STF 2405.
43. In Scutum. Slight increase in position angle. Spect. B9.
44. Theta or 63 Serpentis. AB = relfix; cpm. AC = sep. dec. Spect. A5V, A5V, G5.
45. In Sagitta. Sep. & p.a. increasing. Spect. G5V.
46. In Lyra. Sep. inc.; p.a. dec. Common proper motion. Spect. B3V, A2.
47. In Lyra. Sep. dec; p.a. inc. Common proper motion. Spect. G1V, G5.
48. In Lyra. Relatively fixed. Common proper motion. Spect. A9III, F0IV.
49. In Cygnus. Sep. & p.a. decreasing. Common proper motion. Spect. G5, G4V.
50. In Cygnus. Relatively fixed. Spect. A0.
51. In Lyra. Position angle increasing. Spect. B8V, F5.
52. In Aquila. Sep. & p.a. slightly decreasing. Spect. K2.
53. In Vulpecula. Sep. & p.a. decreasing. Spect. A2, A2.
54. In Vulpecula. AB = sep. dec. AC = relatively fixed. Spect. B7V, B7V, B5.
55. In Cygnus. Separation slightly decreasing. Spect. A0.
56. In Cygnus. Relatively fixed. Spect. S, A5.
57. In Vulpecula. Relatively fixed. Common proper motion. Spect. F5.
58. In Sagitta. Relatively fixed. Common proper motion. Spect. A2, A2.
59. In Cygnus. Relatively fixed.
60. In Cygnus. Relatively fixed. Common proper motion.
61. In Vulpecula. AB = p.a. dec.; cpm. AC = p.a. dec. Spect. A0, A0, A5.
62. In Aquila. Common proper motion; p.a. slightly decreasing. Spect. A0, A0.
63. In Cygnus. Separation slightly decreasing.
64. In Aquila. Sep. & p.a. increasing. Spect. A0V.
65. In Cygnus. Position angle increasing. Spect. A0.
66. In Sagittarius. Position angle slightly decreasing. Spect. A3V.
67. In Cygnus. Slight decrease in p.a. Spect. B.5IV, B.5IV.
68. In Cygnus. Sep. increasing; p.a. decreasing. Spect. A0, A0.
69. In Cygnus. AB = sep. inc. A, B, & C = common proper motion. Spect. F7V.
70. In Cygnus. Separation slightly decreasing. Spect. A2V, A0.
71. In Cygnus. Position angle decreasing. Spect. A0II, B9V.
72. In Cygnus. Common proper motion. Near ES 1674. Spect. B.
73. In Cygnus. Sep. inc; p.a. dec; common proper motion. Spect. A2V, A2V.
74. In Cygnus. Relatively fixed. Spect. B9V, A5.
75. In Cygnus. Position angle slightly decreasing. Spect. B9, B.
76. In Vulpecula. Sep. increasing; p.a. decreasing. Spect. G0, F8.
77. In Cygnus. Common proper motion; p.a. decreasing. Spect. B9, B9.

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78. In Delphinus. Separation slightly decreasing. Spect. F8.
79. In Delphinus. Relatively fixed. Common proper motion. Spect. F8.
80. In Vulpecula. Sep. & p.a. decreasing. Spect. A2.
81. In Delphinus. Sep. & p.a. inc.; cpm. Spect. K0, K0.
82. Gamma or 12 Delphini. Sep. & p.a. dec; cpm. Spect. K1V, F7V.
83. In Vulpecula. Separation increasing. Spect. K5III.
84. In Equuleus. Position angle decreasing. Spect. F8, F8.
85. In Cygnus. Common proper motion; p.a. increasing. Spect. G5, G5.
86. In Cygnus. Separation slightly decreasing. Spect. A2, A0.
87. In Cygnus. Sep. & p.a. increasing. Spect. B9V.
88. In Cygnus. Common proper motion. Position angle decreasing.
89. In Cygnus. Sep. increasing; p.a. decreasing. Spect. F0.
90. In Pegasus. Position angle slightly decreasing. Spect. A3.
91. In Cygnus. Relatively fixed. Common proper motion. Spect. A5, A5.
92. In Cygnus. Separation slightly increasing. Spect. C6II.
93. In Pegasus. Relatively fixed. Common proper motion. Spect. A2, F2V.

Dave Arnold has been involved in the current double star measuring program since April 2001. He has previously published 23 double star research reprts in the Double Star Observer *as well as 10 previous reports in the* Journal of Double Star Observations. *During this time, several new double star systems, or additional components for existing double star systems, have been discovered.*