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Some 2015 Measurements of Wide and Faint Double Stars Compared with Visual Observations

Wilfried R.A. Knapp
Vienna, Austria
wilfried.knapp@gmail.com

Abstract: A backlog of astrometry and photometry measurements made in 2015 for comparison with visual observations is reported here with the intention of providing recent precise measurements for the given objects

Report

Visual observations often pose questions when comparing the impressions with the parameters listed in the Washington Double Star catalog and often questions arise during session planning. To countercheck such impressions, I made measurements based on images made with a remote telescope. In most cases the measurement results confirmed the need for updating the current WDS catalog data, but in some cases the data made evident that visual impressions can sometimes be very misleading.

The WDS catalog data from the end of 2015 for the studied objects is listed in Table 1.

The measurement results are given in Table 2 with the Notes column providing additional information

Table 1: WDS catalog values for the selected objects intended for comparison with visual observation

WDS ID	Name		RA	Dec	Sep	M1	M2	PA	Con
20197+3743	ES 2505	AB	20:19:42.582	+37:43:16.797	8.3	8.65	12.1	247	Cyg
20257+3745	FOX 36	AB	20:25:46.230	+37:46:08.198	2.6	11.5	12	325	Cyg
20208+3748	SEI1095	AB	20:20:50.361	+37:48:07.701	24.7	11.63	12.13	63	Cyg
20216+3725	SEI1100	AB	20:21:38.680	+37:25:15.097	7.2	10.66	12.2	286	Cyg
20216+3725	SEI1100	AC	20:21:38.680	+37:25:15.097	15.4	10.66	12.5	129	Cyg
20310+2036	BU3 63	AB	20:30:58.097	+20:36:21.603	6.6	6.18	12	81	Del
20310+2036	BU 363	AC	20:30:58.097	+20:36:21.603	54.1	6.18	13	206	Del
20526+0517	GCB 75	AB	20:52:34.580	+05:18:26.001	3.4	12	12.4	106	Del
20244+1935	STF2679	AC	20:24:22.589	+19:34:30.003	39.2	7.88	11.56	151	Del
20435+1953	STF2721	AB	20:43:29.802	+19:52:52.199	2.5	7.8	9.9	22	Del
05107+1630	HJ 3268	AB	05:10:41.780	+16:30:43.698	10.1	9.78	11.3	272	Tau
05119+1645	HJ 3269	AB	05:11:53.009	+16:44:30.797	20.1	8.7	10.78	61	Tau
05247+2009	J 145	AB	05:24:45.940	+20:08:58.502	2.7	9.4	9.4	348	Tau
05499+2259	POU 789	AB	05:49:53.620	+22:58:47.600	12.9	8.99	10.7	251	Tau
03474+2355	STF 450	AB	03:47:24.410	+23:54:52.802	6.3	7.29	9.4	263	Tau
05275+2004	BRT2325	AB	05:27:28.830	+20:03:52.903	3.8	10.7	11.3	134	Tau
19385+1715	BU 1471	AB	19:38:27.479	+17:15:26.003	12.4	7.51	11.86	332	Sge
19401+1801	J 121	AB	19:40:05.779	+18:00:50.201	29.8	4.37	13.2	180	Sge
19155+2721	BRT3339	AB	19:15:30.631	+27:20:57.502	3.7	10.7	12.4	48	Lyr
19173+2702	BRT3340	AB	19:17:17.762	+27:01:39.502	4.8	11.9	12.7	61	Lyr
19088+3419	POP 30	AB	19:08:45.922	+34:18:55.904	2.1	9.2	9.7	314	Lyr
18000+5316	A 1886	AB	17:59:58.929	+53:16:16.300	4.7	9.4	10.5	341	Dra
17511+5523	HO 71	AB	17:50:57.763	+55:23:17.900	3.8	9.2	9.6	227	Dra
17452+5157	STF2225	AB	17:45:10.073	+51:56:55.897	5.5	9	11.9	338	Dra
17452+5157	STF2225	CD	17:44:47.572	+51:55:17.198	8.9	10.2	10.56	298	Dra
17027+5952	STI813	AB	17:02:39.048	+59:52:07.794	11	10.41	11.1	67	Dra

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about the used images and references to visual observation. In Table 2 RA and Dec are the coordinates based on plate solving with UCAC4 reference stars in the 10.5 to 14.5mag range. Sep is separation calculated as

$$Sep = \sqrt{\left[\left(RA_2 - RA_1\right)\cos(dec_1)\right]^2 + \left(dec_2 - dec_1\right)^2}$$

in radians. Err_Sep is calculated as

$$Err\_Sep = \sqrt{dRA^2 + dDec^2}$$

with dRA and $dDec$ as average RA and Dec plate solving errors. PA is calculated as

$$PA = \arctan\left[\frac{\left(RA_2 - RA_1\right)\cos(Dec_1)}{Dec_2 - Dec_1}\right]$$

in radians depending on quadrant. Err_PA is the error estimation for PA calculated as

$$Err\_PA = \arctan(Err\_Sep / Sep)$$

in degrees assuming the worst case that Err_Sep points in the right angle to the direction of the separation means perpendicular to the separation vector.

Mag is the photometry result based on UCAC4 reference stars with Vmags between magnitudes 10.5 and 14.5. Results for stars significantly brighter than 10.5 mag are for this reason not reliable and therefore not listed. Err_Mag is calculated as

$$Err\_Mag = \sqrt{dV_{mag}^2 + \left[2.5\log_{10}\left(1 + 1/SNR\right)\right]^2}$$

with dVmag as the average Vmag error over all used reference stars and SNR is the signal to noise ratio for the given star.

Date is the Bessel epoch in 2015 and N is the number of images (usually with one second exposure time) used for the reported values. iT in the Notes column indicates the telescope used with number of images and exposure time given.

Telescope Magnitude Resolution Limit Determination

Additionally a few wide multiples (BU 298, BAR 1 and SMR 33) were used to determine the current telescope magnitude resolution limit for visual observation sessions. For this purpose images and measurements were made to simply provide reliable magnitudes.

The measurement results are given in Table 3 with the Notes column providing additional information about the used images and references to visual observation and current end of 2015 WDS catalog data. Column headings are the same as described above for the Table 2 headings.

Specifications of the used iTelescope equipmentare as follows:

iT24: 610mm CDK with 3962mm focal length. CCD: FLI-PL09000. Resolution 0.62 arcsec/pixel. V-filter. No transformation coefficients available. Located in Auberry, California. Elevation 1405m

Astrometry Quality Control:

A few of the listed objects were selected by random for the purpose of quality control by comparison with URAT1 coordinates (considered the currently most precise available even if preliminary) if available for both components with the results listed below in Table 4.

All checked astrometry results were within the given error range estimation confirmed by comparison with the URAT1 coordinates. Comparison of measured magnitudes with URAT Vmags were only possible for a smaller number of objects with several results outside the given error range estimation but only by a very small margin.

Acknowledgements

The following tools and resources have been used for this research:

- Washington Double Star Catalog
- iTelescope
- AAVSO VPhot
- AAVSO APASS
- UCAC4 catalog via the University of Heidelberg website and directly from USNO DVD
- Aladin Sky Atlas v8.0
- SIMBAD, VizieR
- 2MASS All Sky Catalog
- URAT1 Survey (preliminary)
- AstroPlanner v2.2
- MaxIm DL6 v6.08
- Astrometrica v4.8.2.405

References

Buchheim, Robert – 2008, CCD Double-Star Measurements at Altimira Observatory in 2007, Journal of Double Star Observations, Vol. 4 No. 1 Page 28

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Table 2. Photometry and strometry results for the given objects.

WDS ID	Name		RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
20197+3743	ES 2505	A	20 19 42.595	37 43 17.03	0.09	0.08	8.307	0.120	246.895	0.830	-	-	-	0.07	2015.765	5	1
		B	20 19 41.951	37 43 13.77							14.531	0.097	15.61				
20257+3745	FOX 36	A	20 25 46.251	37 46 08.51	0.19	0.16	2.769	0.248	321.931	5.126	11.342	0.121	68.72	0.12	2015.886	1	2
		B	20 25 46.107	37 46 10.69							11.804	0.122	52.12				
20208+3748	SEI1095	A	20 20 50.356	37 48 07.79	0.13	0.13	24.662	0.184	62.938	0.427	11.557	0.042	91.44	0.04	2015.765	5	3
		B	20 20 52.209	37 48 19.01							12.097	0.043	69.61				
20216+3725	SEI1100	A	20 21 38.683	37 25 15.15	0.12	0.11	7.224	0.163	286.319	1.291	10.524	0.051	145.87	0.05	2015.765	5	4
		B	20 21 38.101	37 25 17.18							11.537	0.051	90.73				
20216+3725	SEI1100	A	20 21 38.683	37 25 15.15	0.12	0.11	15.374	0.163	128.783	0.607	10.524	0.051	145.87	0.05	2015.765	5	5
		C	20 21 39.689	37 25 05.52							11.842	0.051	90.73				
20310+2036	BU 363	A	20 30 58.267	20 36 23.06	0.14	0.15	5.719	0.205	87.795	2.055	-	-	-	0.15	2015.716	1	6
		B	20 30 58.674	20 36 23.28							12.255	0.170	12.95				
20310+2036	BU 363	A	20 30 58.267	20 36 23.06	0.14	0.15	54.714	0.205	206.536	0.215	-	-	-	0.15	2015.716	1	7
		C	20 30 56.526	20 35 34.11							13.580	0.154	31.22				
20526+0517	GCB 75	A	20 52 34.579	05 18 26.26	0.15	0.16	3.260	0.219	101.323	3.849	12.722	0.124	34.08	0.12	2015.683	1	8
		B	20 52 34.793	05 18 25.62							13.739	0.141	14.27				
20244+1935	STF2679	A	20 24 22.580	19 34 29.56	0.15	0.14	38.510	0.205	149.791	0.305	-	-	-	0.07	2015.716	1	9
		C	20 24 23.951	19 33 56.28							11.579	0.071	78.75				
20435+1953	STF2721	A	20 43 29.763	19 52 52.03	0.17	0.14	2.566	0.220	21.951	4.905	-	-	-	0.09	2015.716	1	10
		B	20 43 29.831	19 52 54.41							10.090	0.092	61.17				
05107+1630	HJ 3268	A	05 10 41.762	16 30 44.26	0.16	0.16	10.038	0.226	269.772	1.291	-	-	-	0.14	2015.963	1	11
		B	05 10 41.064	16 30 44.22							11.140	0.141	71.77				

Table 2 (conclusion). Photometry and strometry results for the given objects.

WDS ID	Name		RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
05119+1645	HJ 3269	A	05 11 53.087	16 44 29.54	0.14	0.12	19.983	0.184	60.434	0.529	-	-	-	0.11	2015.963	1	12
		B	05 11 54.297	16 44 39.40							11.142	0.111	62.44				
05247+2009	J 145	A	05 24 45.998	20 08 55.66	0.20	0.20	2.293	0.283	346.506	7.031	10.921	0.122	43.68	0.12	2015.963	1	13
		B	05 24 45.960	20 08 57.89							11.967	0.132	19.00				
05499+2259	POU 789	A	05 49 53.601	22 58 47.50	0.17	0.16	12.655	0.233	251.097	1.057	-	-	-	0.11	2015.963	1	14
		B	05 49 52.734	22 58 43.40							10.905	0.111	84.24				
03474+2355	STF 450	A	03 47 24.428	23 54 52.19	0.19	0.13	6.215	0.230	261.300	2.122	-	-	-	0.11	2015.963	1	15
		B	03 47 23.980	23 54 51.25							9.822	0.112	57.01				
05275+2004	BRT2325	A	05 27 28.838	20 03 52.76	0.19	0.26	3.441	0.322	127.402	5.347	10.601	0.163	32.70	0.16	2015.965	1	16
		B	05 27 29.032	20 03 50.67							11.475	0.174	15.35				
19385+1715	BU 1471	A	19 38 27.500	17 15 25.15	0.21	0.18	12.968	0.277	332.857	1.222	-	-	-	0.11	2015.765	5	17
		B	19 38 27.087	17 15 36.69							12.047	0.115	32.95				
19401+1801	J 121	A	19 40 05.837	18 00 48.80	0.20	0.16	28.900	0.256	180.085	0.508	-	-	-	0.12	2015.768	1	18
		B	19 40 05.834	18 00 19.90							12.951	0.136	16.60				
19155+2721	BRT3339	A	19 15 30.628	27 20 57.18	0.14	0.14	3.683	0.198	45.748	3.077	12.202	0.151	67.04	0.15	2015.754	5	19
		B	19 15 30.826	27 20 59.75							13.119	0.152	39.37				
19173+2702	BRT3340	A	19 17 17.764	27 01 39.33	0.14	0.15	4.913	0.205	59.550	2.391	11.633	0.151	67.55	0.15	2015.754	5	20
		B	19 17 18.081	27 01 41.82							12.338	0.151	52.68				
19088+3419	POP 30	A	19 08 45.942	34 18 56.06	0.17	0.16	1.890	0.233	312.213	7.041	11.845	0.192	40.77	0.19	2015.765	5	21
		B	19 08 45.829	34 18 57.33							12.012	0.192	40.16				
18000+5316	A 1886	A	17 59 58.907	53 16 16.43	0.12	0.11	4.709	0.163	340.528	1.980	-	-	-	0.06	2015.710	1	22
		B	17 59 58.732	53 16 20.87							11.235	0.061	96.37				
17511+5523	HO 71	A	17 50 58.116	55 23 20.77	0.17	0.16	4.131	0.233	230.283	3.234	11.479	0.101	75.16	0.10	2015.710	1	23
		B	17 50 57.743	55 23 18.13							11.998	0.102	49.18				
17452+5157	STF2225	A	17 45 10.081	51 56 56.31	0.13	0.15	5.477	0.198	338.616	2.076	-	-	-	0.05	2015.710	1	24
		B	17 45 09.865	51 57 01.41							11.932	0.054	53.16				
17452+5157	STF2225	C	17 44 47.593	51 55 17.59	0.13	0.15	8.607	0.198	295.461	1.321	10.264	0.050	169.54	0.05	2015.710	1	25
		D	17 44 46.753	51 55 21.29							10.592	0.051	133.26				
17452+5157	B 9005	C	17 44 47.593	51 55 17.59	0.13	0.15	65.088	0.198	302.467	0.175	10.264	0.050	169.54	0.05	2015.710	1	26
		E	17 44 41.657	51 55 52.53							13.077	0.056	42.28				
17027+5952	STI 813	A	17 02 39.057	59 52 07.50	0.13	0.11	11.137	0.170	65.604	0.876	10.230	0.060	145.52	0.06	2015.710	1	27
		B	17 02 40.404	59 52 12.10							12.035	0.062	69.15				

Notes to Table 2.

1. iT24 stack 5x3s. SNR B<20. Visual observation suggested B far fainter than 12.1mag, confirmed
2. iT24 1x3s. Touching to overlapping star disks. Visual observation suggested A and B a tad brighter than listed, confirmed
3. iT24 stack 5x3s. Visual observation suggested B somewhat fainter, not confirmed by this measurement
4. iT24 stack 5x3s. Visual observation suggested B brighter than listed, confirmed
5. iT24 stack 5x3s. Visual observation suggested C brighter than listed, confirmed
6. iT24 1x3s. SNR for B<20. Visual observation suggested B far fainter than 10mag (old WDS August 2013 value in my session plan, meanwhile corrected to estimated 12). But Sep and PA also quite different
7. iT24 1x3s. Zero digit WDS mag for C suggested check
8. iT24 1x3s. SNR for B<20. WDS mags of 12/12.4 suggested check for good reason. No visual observation
9. iT24 1x3s. Visual observation suggested C far brighter than 12.3mag (old WDS August 2013 value in my session plan, meanwhile corrected to 11.56 confirmed by measurement)
10. iT24 1x3s. Visual observation suggested B far fainter than 9.9mag – not supported by this measurement but overlapping star disks might make B probably appear brighter than it really is
11. iT24 1x3s. Visual observation suggested B a bit brighter than 11.3, confirmed
12. iT24 1x3s. Visual observation suggested B fainter than 10.6 (WDS August 2013 value, meanwhile changed to 10.78), confirmed
13. iT24 1x3s. Visual observation suggested A and B far fainter than 9.4mag, confirmed
14. iT24 1x3s. Single digit WDS magnitude for B suggested check
15. iT24 1x3s. Touching star disks. Visual impression of B being reddish and fainter than currently listed and also than measured here
16. iT24 1x3s. SNR for B<20. Visual observation suggests B a bit fainter than 11.3mag, confirmed
17. iT24 stack 5x3s. Visual observation suggested B being fainter than 11.86mag – not really confirmed by this measurement, may be a tad
18. iT24 1x3s. SNR for B<20. Single digit WDS magnitude for B suggested a check
19. iT24 stack 5x3s. Visual observation suggested A much fainter than WDS 10.7mag. Confirmed by measurement
20. iT24 stack 5x3s. Visual impression A and B a tad brighter than WDS listed, confirmed
21. iT24 stack 5x3s. Heavily overlapping star disks - so this measurement is not very reliable. But the visual impression that this double is far fainter than WDS 9.2/9.7mag is certainly confirmed
22. iT24 1x3s. Visual observation suggested B being fainter than WDS 10.5 confirmed by measurement
23. iT24 1x3s. Visual observation suggested A and B being far fainter than WDS 9.2/9.6, confirmed
24. iT24 1x3s. Single digit WDS 11.9mag suggested check
25. iT24 1x3s. Visual observation suggested D being brighter than WDS 10.56mag, but this was not confirmed
26. iT24 1x3s. Part of STF 2225. WDS data confirmed
27. iT24 1x3s. Visual observation suggested B being fainter than WDS 11.1mag, confirmed

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Table 3. Photometry and Astrometry Results for Objects Selected for Telescope Magnitude Resolution Limit Determination

WDS ID	Name		RA	Dec	dRA	dDec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	SNR	dVmag	Date	N	Notes
20396+1555	α Del BU 298	A	20 39 38.364	15 54 43.16	0.17	0.16	35.461	0.233	232.759	0.377	-	-	-	0.10	2015.716	1	1
		B	20 39 36.407	15 54 21.70							13.717	0.109	24.15				
20396+1555	HJ 1554	A	20 39 38.364	15 54 43.16	0.17	0.16	48.276	0.233	277.762	0.277	-	-	-	0.10	2015.716	1	2
		C	20 39 35.048	15 54 49.68							11.977	0.101	63.80				
20396+1555	BU 298	A	20 39 38.364	15 54 43.16	0.17	0.16	45.377	0.233	159.706	0.295	-	-	-	0.10	2015.716	1	3
		D	20 39 39.455	15 54 00.60							12.517	0.102	50.02				
20396+1555	BU 298	A	20 39 38.364	15 54 43.16	0.17	0.16	57.245	0.233	303.505	0.234	-	-	-	0.10	2015.716	1	4
		E	20 39 35.055	15 55 14.76							13.540	0.108	25.87				
20396+1555	BU 298	A	20 39 38.364	15 54 43.16	0.17	0.16	72.217	0.233	117.664	0.185	-	-	-	0.10	2015.716	1	5
		F	20 39 42.798	15 54 09.63							11.818	0.101	71.15				
01097+3537	β And BAR 1	A	01 09 44.155	35 37 12.73	0.13	0.15	108.365	0.198	276.209	0.105	-	-	-	0.09	2015.940	1	6
		C	01 09 35.320	35 37 24.45							13.272	0.109	17.26				
01097+3537	BAR 1	A	01 09 44.155	35 37 12.73	0.13	0.15	65.920	0.198	149.400	0.173	-	-	-	0.09	2015.940	1	7
		D	01 09 46.907	35 36 15.99							11.917	0.094	39.43				
01097+3537	BAR 1	A	01 09 44.155	35 37 12.73	0.13	0.15	155.244	0.198	303.294	0.073	-	-	-	0.09	2015.940	1	8
		E	01 09 33.513	35 38 37.95							11.942	0.094	40.35				
01097+3537	BAR 1	A	01 09 44.155	35 37 12.73	0.13	0.15	141.806	0.198	81.079	0.080	-	-	-	0.09	2015.940	1	9
		F	01 09 55.644	35 37 34.72							11.608	0.093	46.30				
01097+3537	BAR 1	A	01 09 44.155	35 37 12.73	0.13	0.15	205.210	0.198	214.838	0.055	-	-	-	0.09	2015.940	1	10
		G	01 09 34.541	35 34 24.30							12.233	0.095	35.34				
01097+3537	BAR 1	A	01 09 44.155	35 37 12.73	0.13	0.15	231.197	0.198	224.476	0.049	-	-	-	0.09	2015.940	1	11
		H	01 09 30.871	35 34 27.76							11.087	0.092	61.46				
01097+3537	BAR 1	A	01 09 44.155	35 37 12.73	0.13	0.15	335.157	0.198	294.307	0.034	-	-	-	0.09	2015.940	1	12
		I	01 09 19.105	35 39 30.69							11.862	0.094	41.45				
18369+3846	Vega SMR 33	A	18 36 56.604	38 47 05.08	0.13	0.19	221.284	0.230	85.064	0.060	-	-	-	0.11	2015.754	5	13
		P	18 37 15.459	38 47 24.12							12.548	0.113	38.42				
18369+3846	SMR 33	A	18 36 56.604	38 47 05.08	0.13	0.19	167.577	0.230	120.214	0.079	-	-	-	0.11	2015.754	5	14
		Q	18 37 08.989	38 45 40.75							13.406	0.116	28.44				
18369+3846	SMR 33	A	18 36 56.604	38 47 05.08	0.13	0.19	180.481	0.230	264.841	0.073	-	-	-	0.11	2015.754	5	15
		R	18 36 41.231	38 46 48.85							13.217	0.115	32.52				
18369+3846	SMR 33	A	18 36 56.604	38 47 05.08	0.13	0.19	220.794	0.230	246.070	0.060	-	-	-	0.11	2015.754	5	16
		T	18 36 39.344	38 45 35.52							12.876	0.113	38.73				

Notes to Table 3.

1. iT24 1x3s image taken for TML check. Sep and PA according to WDS values, Mag B about 0.3mag fainter than WDS listed
2. iT24 1x3s image taken for TML check. Part of BU298. Visual observation suggested C fainter than listed, not confirmed
3. iT24 1x3s image taken for TML check. Sep and PA according to WDS values, Mag D about 0.4mag brighter than listed
4. iT24 1x3s image taken for TML check. Sep and PA according to WDS values, Mag E about 0.9mag fainter than listed
5. iT24 1x3s image taken for TML check. Sep and PA according to WDS values, Mag F about 1.1mag fainter than listed
6. iT24 1x3s taken for TML check. SNR for C<20. C about 0.3mag fainter than listed
7. iT24 1x3s taken for TML check. WDS mag for D about confirmed
8. iT24 1x3s taken for TML check. WDS mag for E confirmed
9. iT24 1x3s taken for TML check. WDS mag for F confirmed
10. iT24 1x3s taken for TML check. G about 0.3mag fainter than listed
11. iT24 1x3s taken for TML check. C about 0.3mag fainter than listed
12. iT24 1x3s taken for TML check. WDS mag for I about confirmed
13. iT24 stack 5x3s taken for TML check. P about 0.5mag fainter than listed
14. iT24 stack 5x3s taken for TML check. Q about 1.4mag fainter than listed
15. iT24 stack 5x3s taken for TML check. R about 1.2mag fainter than listed
16. iT24 stack 5x3s taken for TML check. T about 0.3mag fainter than listed

Table 4: Quality control of measurements by comparison with URAT1

WDS ID	Name		RA	Dec	Sep	✓	PA	✓	Mag	✓	Date	Notes
20208+3748	SEI1095	A	20 20 50.363	37 48 07.729	24.670	Yes	62.733	Yes	11.633	No	2013.658 2013.677	"No" for M1 with small margin of 0.034
		B	20 20 52.213	37 48 19.031					12.125	Yes		
05275+2004	BRT2325	A	05 27 28.840	20 03 51.861	3.423	Yes	132.316	Yes	10.443	Yes	2013.890 2014.044	Vmag not available for B in URAT1
		B	05 27 29.020	20 03 49.556					na	-		
18000+5316	A 1886	A	17 59 58.913	53 16 16.315	4.700	Yes	340.223	Yes	9.471	-	2013.668 2013.898	Vmag not available for B in URAT1, A not measured
		B	17 59 58.736	53 16 20.738					na	-		
17452+5157	B 9005	A	17 44 47.583	51 55 17.412	65.349	Yes	302.524	Yes	na	-	2013.628 2013.897	"No" for M2 with small margin of 0.003. Vmag for A not available in URAT1
		B	17 44 41.627	51 55 52.547					13.018	No		
17027+5952	STI 813	A	17 02 39.047	59 52 07.516	11.028	Yes	66.433	Yes	10.148	No	2013.668 2013.898	"No" for M1 with small margin of 0.022. Vmag for B not available in URAT1
		B	17 02 40.390	59 52 11.925					na	-		

Visual Observation and Measurements of Some Tycho Double Stars

Wilfried R.A. Knapp
Vienna, Austria
wilfried.knapp@gmail.com

Ross Gould
Double Star Notes, Australian Sky & Telescope
Canberra, ACT, Australia
rgould1792@optusnet.com.au

Abstract: No humble human visual observer would dare to challenge a robotic telescope – yet many Tycho based results are highly questionable to utterly wrong as is shown on several examples.

1. Introduction

Several years ago I observed mostly STF doubles as these objects have a record with many observations, are well documented, and reasonable targets for small amateur telescopes. Session planning based on the current WDS catalog data at the time of the observations assumed that recent measurements would provide most precise data. One of the selected objects was STF442, with 2.5" separation and magnitudes 10.06 and 13.0 (WDS values per end of 2014) – obviously not suited for a 120mm refractor, so it took me some time to give it a try in a night with excellent seeing. To my surprise resolution was easy and both components were rather equal bright. I checked then the STF catalog directly and found that F. Struve estimated the components had magnitudes 9.9 and 10.4. I then contacted Brian Mason at the USNO and it was determined that the 13 magnitude for the companion was based on Tycho, but obviously wrong, and the WDS catalog entry was accordingly changed to 10.5 magnitude for the secondary to keep the original Δm. This was my first experience with incorrect Tycho data; anecdotal evidence and no reason for a follow up.

But recently I selected objects from the WDS catalog double stars suited for observation with telescopes in the 150 to 200 mm aperture range in Cygnus. This resulted in several hundred doubles with different discoverer designations, but a good part were TDS and TDT objects in the range of 1.5 to 2.5" separation and brightness in the 11 to 12 magnitude range. First, visual observation results were not very convincing, so I checked the data on these objects in more detail. I noticed for the first time that most of these objects showed only one first/last observation indicating that Tycho was not only the "discoverer" of these doubles, but that so far no other observations were available to confirm these "discoveries".

I then checked directly the Tycho Double Star catalog and found about 98,000 objects meaning about 49,000 doubles as all components were listed separately. About 80% of these objects show a WDS ID indicating that they are included in the WDS catalog, but mostly with well-known discoverer designations. Why the rest is not included in the WDS catalog is not entirely clear to me, but I assume the data for these objects is suspect from the first impression.

I then checked the WDS catalog and found about 9,800 objects with a TDS designation and about 4,200 objects with a TDT designation, so we have in total about 14,000 WDS objects with Tycho as discoverer (most or all of them obviously based on the report of Fabricius *et al.*, 2002) As mentioned before, most of them are without a confirming second observation. The vast majority of these objects are in the range of less than 1" separation with quite faint components. So they are not really suited for visual amateur observation and certainly also quite difficult for imaging unless perhaps with speckle interferometry. From the less than 3000 TDS objects with separation 1.5" or larger only about 600 show at least a second confirming observation and about 200 are listed with "X" in the notes section marking bogus doubles giving a ratio from 3:1 for confirmations against bogus.

I then selected a few of TDS and TDT objects in Cygnus in the 1.5" or larger separation range with only one observation to give it a try with the best suited iTelescope equipment available to me. Images with 3 second exposure time taken with remote telescope iT24 (for specifications see Acknowledgements) should, according to my experience, provide at least significant elongations if not clear separation of such objects, depending on the magnitudes of the components. Table 1 lists the WDS values for these selected objects.

2. Further Research

One image was taken for the selected objects with iT24 with 3 s exposure time; at least this was the intention, because the weather did not cooperate for an extended period, I missed several of the planned objects. The conditions for visual observations were even worse so that I managed this for only a small part of the list. The images I got were initially plate solved with AAVSO VPhot and then processed with Astrometrica with the results given in Table 2 with missed objects not listed.

In the Table 2 headings, "M1(2) new" means photometry result with V-filter for primary and secondary;

$$\mathrm{ErrM1(2)} = \sqrt{dV_{mag}^2 + Err(SNR)^2}$$

"Err M1(2)" stands for the calculated error estimation where dVmag is the average magnitude error from plate solving and SNR is the signal to noise ratio (not reported here). Date is Bessel epoch of observation.

Counter Check

As these results with only one confirmation out of (not counting the one declared bogus) 16 measured objects were not positive, I decided to have a look at Tycho doubles in another constellation high in altitude from a location in Australia. This allowed me to use the iTelescope iT27 with a somewhat better 0.53"/pixel resolution in Siding Spring and to invite Ross Gould to contribute visual observations. The obvious choice was the constellation Phoenix with the unconfirmed TDS/TDT objects selected by separation larger than 1.5 arcseconds (including RST38 suggested by Ross as reference object with similar data but several confirming observations) shown in Table 3.

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Table 1: WDS values per beginning of 2016 for the selected unconfirmed TDS/TDT objects in Cygnus with separation larger than 1.5 arcseconds

Name	Comp	WDS ID	RA	Dec	Sep	M1	M2	PA
TDS1066	AB	20230+3752	20:23:00.563	+37:51:51.507	1.6	11.08	12.15	269
TDS1070	AB	20243+3811	20:24:18.572	+38:10:30.904	1.9	10.53	11.97	203
TDT2234	AB	20236+3817	20:23:38.850	+38:17:03.596	1.9	11.97	12.06	230
TDT3230	AB	21545+4052	21:54:30.980	+40:52:16.198	2.0	12.14	12.23	222
TDT3234	AB	21548+4310	21:54:50.817	+43:09:55.006	2.0	11.34	12.42	343
TDT3212	AB	21525+4332	21:52:31.463	+43:32:11.506	1.7	10.81	12.27	41
TDT3195	AB	21513+4428	21:51:19.262	+44:27:42.396	1.9	11.09	11.98	203
TDT3301	AB	22022+4510	22:02:09.220	+45:09:47.700	1.6	10.93	11.78	121
TDT3131	AB	21448+4534	21:44:48.581	+45:33:32.997	1.7	10.10	12.05	106
TDT3240	AB	21552+4700	21:55:11.829	+47:00:05.905	1.7	11.66	12.10	7
TDT3002	AB	21304+4926	21:30:21.980	+49:26:14.094	2.0	11.30	11.75	295
TDT3180	AB	21495+5019	21:49:32.942	+50:18:44.904	1.9	11.21	12.12	71
TDT3128	AB	21443+5024	21:44:15.801	+50:23:31.702	1.7	11.54	11.99	198
TDT3087	AB	21396+5025	21:39:37.778	+50:25:18.805	1.9	11.31	11.80	126
TDT3281	AB	21599+5116	21:59:51.541	+51:16:26.998	1.9	10.46	12.35	284
TDT3161	AB	21481+5156	21:48:07.138	+51:55:36.795	2.5	10.76	12.38	223
TDT3065	AB	21375+5157	21:37:28.180	+51:57:28.402	1.9	11.72	12.24	88
TDT3015	AB	21322+5336	21:32:09.137	+53:36:10.500	1.9	11.95	12.17	300
TDT3099	AB	21403+5338	21:40:20.439	+53:37:34.106	2.1	11.43	12.27	259
TDT3181	AB	21496+5350	21:49:33.491	+53:50:03.195	1.6	11.63	12.13	265
TDT3135	AB	21451+5432	21:45:08.569	+54:31:40.896	2.2	11.57	12.25	194
TDT3252	AB	21568+5506	21:56:47.059	+55:05:38.200	2.1	11.25	12.35	18

Table 2. Photometry results for the selected TDS/TDT components in Cygnus.

Name	WDS ID	M1 new	Err M1	M2 new	Err M2	Date	Notes
TDS1066	20230+3752	11.065	0.071	-	-	2015.886	No resolution, not even an elongation. Visual observation with 185mm refractor: Only faint single star, no resolution. WDS listed as Bogus and as such confirmed
TDS1070	20243+3811	10.382	0.080	-	-	2015.886	No resolution, not even an elongation. Same result with visual observation with 185mm refractor. Dec position error ~0.6". Bogus assumed
TDT2234	20236+3817	12.284	0.082	-	-	2015.886	No resolution, not even an elongation. Same result with visual observation with 185mm refractor. Bogus assumed
TDT3015	21322+5336	11.812	0.061	-	-	2015.847	No resolution, not even an elongation. No visual observation. Bogus assumed
TDT3065	21375+5157	11.764	0.081	-	-	2015.847	No resolution, not even an elongation. No visual observation. Bogus assumed
TDT3087	21396+5025	11.276	0.091	-	-	2015.847	No resolution, not even an elongation. No visual observation. Bogus assumed
TDT3099	21403+5338	11.689	0.081	-	-	2015.847	No resolution, not even an elongation. No visual observation. Bogus assumed
TDT3131	21448+4534	9.985	0.100	-	-	2015.847	No resolution, not even an elongation. No visual observation. Bogus assumed
TDT3161	21481+5156	10.438	0.090	-	-	2015.847	No resolution, not even an elongation. No visual observation. Bogus assumed
TDT3181	21496+5350	11.604	0.081	-	-	2015.847	No resolution, not even an elongation. No visual observation. Bogus assumed
TDT3195	21513+4428	10.950	0.091	-	-	2015.847	No resolution, not even an elongation. No visual observation. Bogus assumed
TDT3212	21525+4332	10.675	0.081	11.296	0.081	2015.847	Clear elongation with overlapping star disks - border case for separated photometry but possible. Visual observation with 185mm refractor positive - resolution in moments of good seeing
TDT3230	21545+4052	12.098	0.062	-	-	2015.847	No resolution, not even an elongation. No visual observation. Bogus assumed
TDT3234	21548+4310	11.198	0.071	-	-	2015.847	No resolution, not even an elongation. Visual observation with 185mm refractor: Only faint single star, no resolution. Bogus assumed
TDT3240	21552+4700	11.429	0.091	-	-	2015.847	No resolution, not even an elongation. No visual observation. Bogus assumed
TDT3281	21599+5116	10.284	0.100	-	-	2015.847	No resolution, hint of an elongation but with wrong PA. No visual observation. Bogus assumed
TDT3301	22022+4510	10.711	0.080	-	-	2015.847	No resolution, not even an elongation. No visual observation. Bogus assumed

Visual Observation and Measurements of Some Tycho Double Stars

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Photometry and Astrometry in Phoenix

For each selected object, one 3 s image was taken with iT27 and, after the initial plate solving with AAVSO, was VPhot processed with Astrometrica. With the exception of TDT4192 all results listed in Table 4 were instantly obvious. Ross had bad luck with the weather making conclusive visual observation results impossible so we got here only a few hints (see Notes column).

Astrometry results are based on the formulae provided by R. Buchheim (2008) for calculating Sep and PA. Sep is separation and is calculated as

$$\mathrm{Sep} = \sqrt{\left[\left(RA_2 - RA_1\right)\cos(Dec1)\right]^2 + \left(Dec_2 - Dec_1\right)^2}$$

in radians. Err Sep is the error estimation for Sep calculated as

$$\mathrm{Err\ Sep} = \sqrt{dRA^2 + dDec^2}$$

ErrMag is the error estimation for Vmag results calculated as

$$ErrMag = \sqrt{dV_{mag}^2 + ErrSNR^2}$$

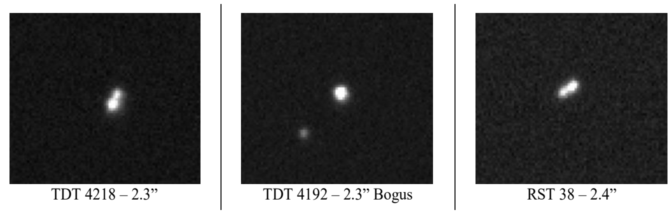

Figure 1. Images of three measured doubles.

with Err_SNR calculated as $2.5*\mathrm{Log}_{10}(1+1/SNR)$.

PA is calculated as

$$PA = \arctan\left[\frac{\left(RA_2 - RA_1\right)\cos(Dec_1)}{Dec_2 - Dec_1}\right]$$

in radians and Err_PA is the error estimation for PA calculated as arctan(Err_Sep/Sep) in degrees, assuming the worst case that dSep points in the right angle to the direction of the separation means perpendicular to the separation vector

Just for visual comparison, Figure 1 shows three images side by side.

Additional Research

This again rather meager result in terms of confirming WDS Tycho Double Stars with only 1 positive

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Table 3: WDS values per beginning of 2016 for the selected TDS/TDT components in Phe plus RST38

WDS ID	Name	RA	Dec	Sep	M1	M2	PA
00065-5200	TDS1294	00:06:31.770	-52:00:17.303	2.3	12.20	13.42	224
00071-4152	TDS1299	00:07:05.950	-41:52:26.896	1.7	12.02	12.13	269
00087-4057	TDS1311	00:08:39.600	-40:56:32.194	2.3	11.56	12.82	137
00166-4347	TDS1376	00:16:34.590	-43:47:25.294	2.9	11.49	13.02	115
00171-5039	TDS1382	00:17:04.210	-50:38:35.794	2.1	11.92	12.97	119
00409-4743	TDS1564	00:40:53.840	-47:42:32.605	1.7	12.75	12.90	251
00467-4805	TDS1608	00:46:43.780	-48:05:18.604	2.3	11.96	13.15	232
01297-4023	TDS1893	01:29:43.220	-40:23:17.200	2.3	11.63	13.31	313
01322-4006	TDS1904	01:32:13.350	-40:05:43.103	1.8	12.35	12.87	69
01440-4538	TDS1973	01:43:57.830	-45:37:54.403	2.5	12.41	12.81	215
01496-4352	TDS2016	01:49:34.610	-43:51:47.799	2.1	11.85	12.25	222
23469-4150	TDT4189	23:46:54.670	-41:50:19.400	2.6	11.79	12.35	211
23472-4204	TDT4192	23:47:13.848	-42:04:22.299	2.3	11.61	12.23	209
23495-3927	TDT4218	23:49:30.992	-39:26:33.196	2.5	11.88	12.38	325
01425-4637	RST38	01:42:32.580	-46:37:04.196	2.4	12.30	12.70	112

Visual Observation and Measurements of Some Tycho Double Stars

Table 4. Photometry and Astrometry Results for the Selected TDS Objects in Phoenix.

Name		RA	Dec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	Date	N	Notes
TDS1294	A	00 06 31.835	-52 00 17.58	-	0.205	-	-	12.483	0.083	2015.908	1	iT27 1x3s. No resolution, not even a hint for an elongation. Bogus assumed
	B							-	-			
TDS1299	A	00 07 06.016	-41 52 26.86	-	0.206	-	-	12.098	0.064	2015.908	1	iT27 1x3s. No resolution, not even a hint for an elongation. Bogus assumed
	B							-	-			
TDS1311	A	00 08 39.625	-40 56 32.16	-	0.242	-	-	11.704	0.062	2015.908	1	iT27 1x3s. No resolution, not even a hint for an elongation. Bogus assumed
	B							-	-			
TDS1376	A	00 16 34.618	-43 47 24.98	-	0.184	-	-	11.970	0.082	2015.908	1	iT27 1x3s. No resolution, not even a hint for an elongation. Visual impression also rather single star. Bogus assumed
	B							-	-			
TDS1382	A	00 17 04.260	-50 38 36.15	-	0.178	-	-	11.994	0.092	2015.908	1	iT27 1x3s. No resolution, not even a hint for an elongation. Bogus assumed
	B							-	-			
TDS1564	A	00 40 53.893	-47 42 32.70	-	0.304	-	-	12.547	0.062	2015.908	1	iT27 1x3s. No resolution, not even a hint for an elongation. Bogus assumed
	B							-	-			
TDS1608	A	00 46 43.812	-48 05 18.69	-	0.170	-	-	11.988	0.072	2015.908	1	iT27 1x3s. No resolution, not even a hint for an elongation. Bogus assumed
	B							-	-			
TDS1893	A	01 29 43.261	-40 23 17.39	-	0.186	-	-	11.501	0.072	2015.908	1	iT27 1x3s. No resolution, not even a hint for an elongation. Bogus assumed
	B							-	-			
TDS1904	A	01 32 13.359	-40 05 43.03	-	0.198	-	-	12.232	0.093	2015.908	1	iT27 1x3s. No resolution, not even a hint for an elongation. Bogus assumed
	B							-	-			
TDS1973	A	01 43 57.811	-45 37 54.62	-	0.269	-	-	12.394	0.083	2015.908	1	iT27 1x3s. No resolution, not even a hint for an elongation. Bogus assumed
	B							-	-			
TDS2016	A	01 49 34.639	-43 51 48.07	-	0.258	-	-	12.226	0.083	2015.908	1	iT27 1x3s. No resolution, not even a hint for an elongation. Bogus assumed
	B							-	-			
TDT4189	A	23 46 54.673	-41 50 19.96	-	0.227	-	-	11.610	0.093	2015.908	1	iT27 1x3s. No resolution, not even a hint for an elongation. Visual impression probably single. Bogus assumed
	B							-	-			
TDT4192	A	23 47 13.909	-42 04 21.92	-	0.264	-	-	11.574	0.095	2015.908	1	iT27 1x3s. First image suggested hint of elongation - but not confirmed by additional images. Visual impression not conclusive. Bogus assumed
	B							-	-			
TDT4218	A	23 49 31.014	-39 26 33.53	2.295	0.192	324.154	4.785	12.028	0.089	2015.908	1	iT27 1x3s. Touching star disks but rather clear resolution. SNR for B <20. Visual impression also double
	B	23 49 30.898	-39 26 31.67					12.521	0.101			
RST 38	A	01 42 32.548	-46 37 04.20	2.401	0.256	113.310	6.090	12.519	0.085	2015.911	1	iT27 1x3s. Touching star disks. Visual resolution
	B	01 42 32.762	-46 37 05.15					12.891	0.088			

Visual Observation and Measurements of Some Tycho Double Stars

Table 5. Photometry and Astrometry Results for the Selected TDS Objects.

Name		RA	Dec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	Date	N	Notes
TDS2046	A	01 53 51.895	-24 55 11.10	-	0.425	-	-	11.319	0.143	2016.026	1	1
	B								-			
TDS2074	A	01 58 21.221	-30 46 58.76	-	0.228	-	-	12.295	0.062	2016.026	1	2
	B								-			
TDS2106	A	02 05 15.934	-33 54 02.81	-	0.298	-	-	12.184	0.081	2016.026	1	2
	B								-			
TDS2146	A	02 10 45.190	-38 04 56.83	-	0.270	-	-	11.343	0.131	2016.026	1	2
	B								-			
TDS2177	A	02 15 23.165	-24 54 47.45	1.906	0.439	116.827	12.976	11.547	0.072	2016.026	1	3
	B	02 15 23.290	-24 54 48.31					11.769	0.072			
TDS2221	A	02 21 18.345	-38 10 28.25	-	0.286	-	-	11.337	0.100	2016.026	1	2
	B								-			
TDS2264	A	02 29 01.718	-37 16 35.91	1.588	0.248	63.441	8.891	11.700	0.111	2016.026	1	4
	B	02 29 01.837	-37 16 35.20					11.740	0.111			
TDS2447	A	03 06 48.102	-38 09 59.73	-	0.233	-	-	11.105	0.051	2015.999	2	5
	B								-			
TDS2481	A	03 13 08.226	-35 01 08.77	-	0.226	-	-	12.128	0.051	2016.026	1	2
	B								-			
TDS2511	A	03 16 28.792	-32 42 55.90	-	0.177	-	-	11.618	0.061	2016.026	1	2
	B								-			
TDS2543	A	03 25 15.801	-25 00 46.40	-	0.258	-	-	12.566	0.081	2016.026	1	2
	B								-			
TDS2593	A	03 35 21.415	-29 26 38.63	-	0.153	-	-	12.246	0.061	2016.026	1	2
	B								-			

Notes to Table 5.

1. iT27 1x3s. No resolution, not even a hint for an elongation. Bogus assumed
2. iT27 1x3s. No resolution, not even a hint for an elongation. Bogus assumed
3. iT27 1x3s. Overlapping star disks, clear elongation. Confirmed
4. iT27 1x3s. Overlapping star disks, clear elongation. Confirmed. A and B seem equally bright
5. iT27 1x3s. No resolution, not even a hint for an elongation. Same result with a second image. Bogus assumed

out of 14 objects called for just another attempt for a counter check. Beginning of 2016 the constellation For was reasonably high for imaging from Australia so just another set of images with the same selection criterion separation 1.5” or larger was taken with the following results in Table 5. Table headings in Table 5 were calculated as described for Table 4 earlier in this article.

Additional Research

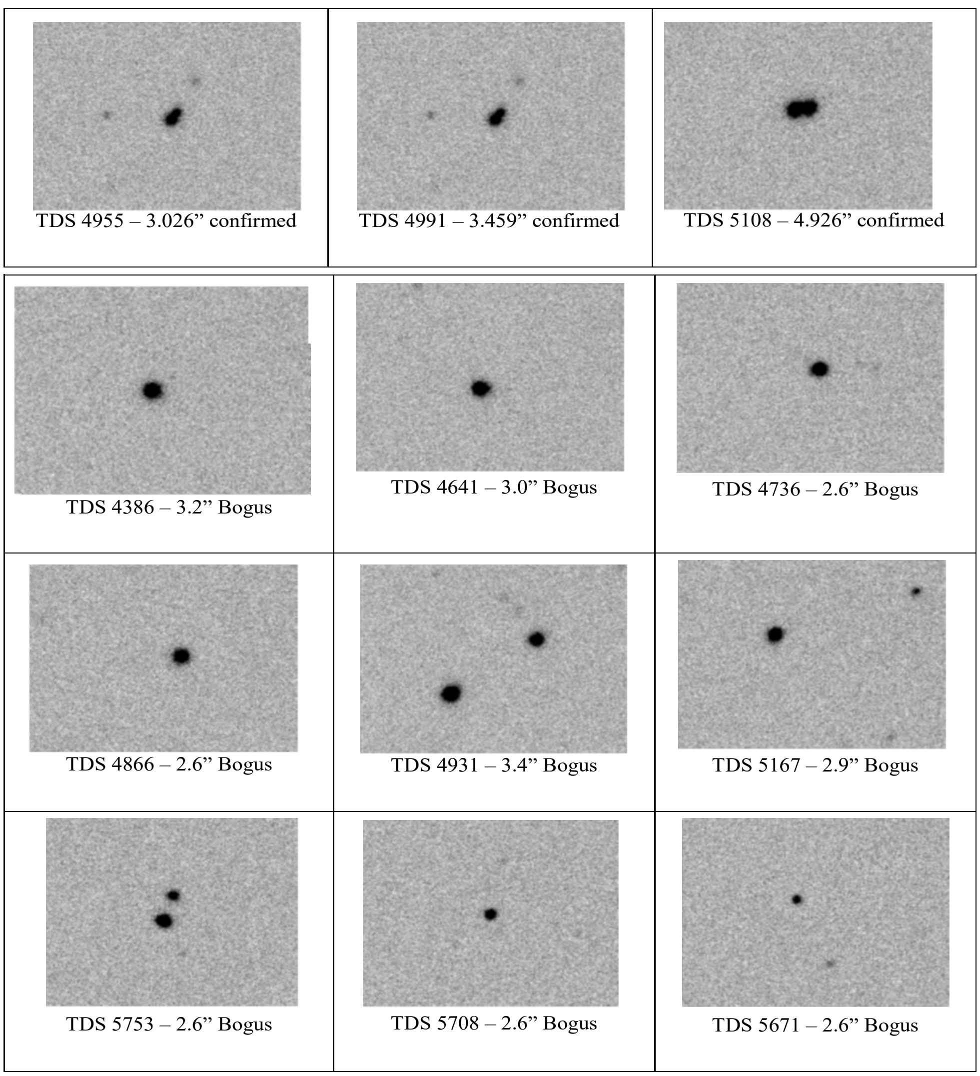
With 2 confirmations out of 12 objects the wider TDS objects in Fornax fared a bit better than in Cygnus and Phoenix. To eliminate all potential doubts in terms of image resolution, I decided to have a look at objects far beyond any such questions in Puppis with 9 already confirmed objects with a separation of at least 2.6 arcseconds.

All these objects were confirmed again with our own measurements. Sep and PA in most cases were within the given error range compared with the values listed in the WDS catalog (in two cases with change of the components A and B according to the magnitude measurement). For the few cases outside the error range a counter check with URAT1 would be helpful for detecting potential proper motion issues, but URAT1 is currently not available for the southern sky.

Surprisingly all of the selected unconfirmed objects with rather comfortable separation have to be assumed bogus. To visualize these results some cut outs from the center of the used images are given in Figure 2.

Closing the Circle

In the final stage of writing this report I got the hint



TDS 4955 – 3.026” confirmed
TDS 4991 – 3.459” confirmed
TDS 5108 – 4.926” confirmed
TDS 4386 – 3.2” Bogus
TDS 4641 – 3.0” Bogus
TDS 4736 – 2.6” Bogus
TDS 4866 – 2.6” Bogus
TDS 4931 – 3.4” Bogus
TDS 5167 – 2.9” Bogus
TDS 5753 – 2.6” Bogus
TDS 5708 – 2.6” Bogus
TDS 5671 – 2.6” Bogus

Figure 3. Image examples for the selected TDS objects in Pup showing confirmed objects versus obvious bogus

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Table 6. Measurement Results for HJ348

Name		RA	Dec	Sep	Err Sep	PA	Err PA	Vmag	Err Vmag	Date
HJ348	A	04 43 04.967	33 55 47.08	30.262	0.318	285.329	0.603	7.315	0.140	2016.085
	B	04 43 02.622	33 55 55.08					11.360	0.149	

that HJ348 (WDS04431+3356 with Sep 30.6" +7.42/9.5mag 286° PA) in Auriga might be listed with a far too bright magnitude for the companion. Measurements based on a stack of 6x1s images taken with iT18 resulted in the following values given in Table 6. This means that the companion is nearly 2 magnitudes fainter than currently listed in the WDS catalog. Checking HJ348 for synonyms I found that this pair is also included in the Tycho Double Star catalog being the source of the wrong magnitude for the companion – similar situation to STF442.

Historical Background to the Tycho Double Star Catalog (by Ross Gould)

The ESA Hipparcos satellite included the Tycho star mapper, which produced a catalogue of single stars, initially (Tycho-I) including just over 1 million stars to magnitude 11.5, with positional and photometric data. The material was re-processed later to yield the Tycho-II catalogue of 2.5 million stars. From this, an initial analysis for double stars produced over 12,000 double star measures including 1234 new double star systems (Mason et al, AJ, 2000 December). Following this, a "dedicated re-reduction of the Tycho data" produced a total of 13,251 discoveries (Hoeg, Fabricius, et al, A&A, 2002 March).

When the Hipparcos double star data had been released effort was made to confirm a good number of the claimed new pairs. This was done by speckle interferometry, these days a 'gold standard' for measures of doubles. Papers by Mason et al in 1999 and 2001 detailed this work (Mason et al, AJ 1999 and 2001). The conclusion, based on "only a subset of the new doubles" was that "most new Hipparcos doubles are bona fide double stars...", despite problems with verification of some of the list, using the McDonald Observatory 2.1metre telescope.

Fast forward a short time, and the new and greatly expanded Tycho Double Star Catalogue is announced, with over ten times as many new doubles as its predecessor, 13,251. The Fabricius 2002 paper provides details of the new analysis. Most of the added objects compared to the first catalogue "have separations between 0.3 and 1.0 arcsec".

The doubles were generated from single star results in combination. Proximity of positions was the criterion, and the separation and angle were calculated from the relative positions. Delta-m was typically no more than 2. Various methods were used in attempting to eliminate spurious detections. There was acknowledgement that the new analysis involved the risk of more spurious detections or of errors in rho and theta.

Because of the generally dim magnitudes of the stars, mostly of 11th and 12th magnitude, these are not easy pairs for re-observing to confirm their reality. Thus, a suggestion made in the Mason 2001 Hipparcos paper was useful, that is, using CCD imaging, as the Tycho doubles are not so close as to require interferometry on large telescopes. That the dim magnitudes are bordering on the practical limits for speckle work, regardless of aperture, also recommends imaging as the best technique. Mason (1999) noted that telescopes larger than the USNO 26-inch (0.7m) refractor did little to increase the magnitude limit but instead reached the same signal-to-noise ratio in less time. Other changes, such as longer exposures, broader waveband filters, or less magnification resulting in less resolution, were unhelpful.

The sheer number of objects listed in the Tycho Double Star Catalogue appears to have discouraged extensive follow-ups on these objects. There are many non-Tycho recorded doubles that are brighter and will therefore attract attention first. Despite the extended TDS Catalogue being available in 2002, the great majority of objects in it have not as yet been confirmed. As of January 2016, Dr. Brian Mason/USNO said that from the total of 14,175 TDS and TDT pairs, 226 appear to be not real, 965 have been confirmed by something other than Hipparcos, and 12,984 are still of unconfirmed status.

The work recorded in the present paper, on some of the easier because wider Tycho doubles, has a much higher rate of bogus doubles than the above numbers. The objects assessed here were chosen from those with only a 1991 observation merely by their separation. Because these are the wider pairs, and much wider than the nominal resolution of Tycho - 0.8" - it is surprising that so few appear to match the Tycho data. A high proportion appear to be bogus doubles in this modest sample. Ongoing work will indicate how representative this sample is, at least for separations above 1.5 arcseconds. The many Tycho doubles that are closer will require for their verification more resolution capability than was used for this study.

Summary

The results based on image processing and a few visual observations show a not positive record for the validity of the WDS catalog data for non-confirmed Tycho Double Stars – less than 10% of the by random selected TDS/TDT objects with separation larger than 1.5 arcseconds were confirmed as double stars and the rest was assumed being bogus without a regular pattern as for example a bright star nearby as is sometimes discussed. There seems to be no reason to consider the huge number of such objects with smaller separation being more reliable. This means that any TDS/TDT object with so far no confirming additional observation is to be considered with a rather high probability as potential bogus and that objects with other designations with Tycho based magnitudes might be better checked for the validity of at least the magnitude of the companion.

Potential further research

Besides continuing to observe and image TDS objects wide enough to be resolved with the given equipment it might be of interest to image also rather close pairs for measurement of the combined magnitude and to compare this value with the calculated combined magnitude based on the current WDS catalog data – crass differences here should indicate questionable objects. Ross is also working on checking wide TDS objects with Sky Survey images as at least a distinctive elongation is to be expected here for existing pairs.

Acknowledgements:

The following tools and resources have been used for this research:

- Washington Double Star Catalog as data source for the selected objects
- iTelescope: Images were taken with
  - iT24: 610mm CDK with 3962mm focal length. CCD: FLI-PL09000. Resolution 0.62 arcsec/pixel. V-filter. Located in Auberry, California. Elevation 1405m
  - iT27: 700mm CDK with 4531mm focal length. CCD: FLI PL09000. Resolution 0.53 arcsec/pixel. V-filter. Located in Siding Spring, Australia. Elevation 1122m
  - iT18: 318mm CDK with 2541mm focal length. CCD: SBIG-STXL-6303E. Resolution 0.73 arcsec/pixel. V-filter. Located in Nerpio, Spain. Elevation 1650m
- AAVSO VPhot for initial plate solving
- AAVSO APASS providing Vmags for faint reference stars (indirect via UCAC4)
- UCAC4 catalog (online via the University of Heidelberg website and Vizier and locally from USNO DVD) for counterchecks and for high precision plate solving
- Tycho Double Star catalog for counterchecks
- Aladin Sky Atlas v8.0 for counterchecks
- SIMBAD, VizieR for counterchecks
- 2MASS All Sky Catalog for counterchecks
- URAT1 Survey (preliminary) for counterchecks
- AstroPlanner v2.2 for object selection, session planning and for catalog based counterchecks
- MaxIm DL6 v6.08 for plate solving on base of the UCAC4 catalog
- Astrometrica v4.8.2.405 for astrometry and photometry measurements

Special thanks to Brian Mason of the USNO for providing the precise numbers of TDS/TDT objects in the WDS catalog. As of 2016 out of a total 14,175 TDS and TDT pairs, 226 appear not to be real, 965 have been confirmed by something other than Hipparcos, and 12,984 are still unknown.

Thanks to Robert Korn for making me aware of the suspect magnitude given for HJ348 B in the WDS catalog.

Thanks to Ross Gould of Australian Sky & Telescope for taking the effort of several attempts to provide visual observation reports for the selected TDS objects in southern constellations only to be frustrated by clouds and poor seeing conditions preventing conclusive visual results

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Double Star Observations with a 150mm Refractor in 2015

Marc Oliver Maiwald
Witten, Germany
oliver-maiwald@web.de

Abstract: I present 136 measurements of 69 pairs made in 2015. For 26 stars, residuals were calculated.

In 2015 the same telescope and observing techniques as in previous years were used (Maiwald, 2013; Maiwald, 2014; Maiwald, 2015), with the only exception of a Alccd QHY 5-II camera with 3.75mm pixels aquired in autumn 2015 and used for 9 observations in autumn and winter. For one observation a Philips SPC 900 NC was used. All other observations were made with an Imaging Source DMK 21 camera.

The imaging scales for the different optical setups are:

- DMK 21 at direct focus (f): 0.384 a.s. per pixel.
- DMK 21 with teleconverter 1.4x (TK 1.4): 0.297322 a.s. per pixel
- DMK 21 with teleconverter 2x (TK 2): 0.19876 a.s. per pixel
- QHY 5 – II at direct focus (f; A) : 0.25739 a.s. per pixel
- QHY 5 – II with teleconverter 1.4 (TK1.4; A): 0.1851 a.s. per pixel
- SPC 900 NC with teleconverter 2x (TK2; NC): 0.2091 a.s. per pixel

Acknowledgements

This paper made use of the Washington Double Star Catalog and the Sixth Catalog of Orbits of Visual Binary Stars, both maintained at the U.S. Naval Observatory. Noncommercial software used was: *Binary Star Calculator* by Brian Worman; *Reduc 3.88* by Florent Losse; *Registax 4 and 5* by Coer Berrevoets and *SharpCap* by Robin Glover.

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Double Star Observations with a 150mm Refractor in 2015

Table 1. Double Star Measurements in 2015

Designation	WDS ident	θ	ρ	Date	No	Name	Notes
STF 060 AB	00491+5749	324.6 324.3	13.44 12.92	2015.781 2015.904	76 37	η Cas	f; A TK2
STF 180	01535+1918	1.1 1.1	7.16 7.14	2015.953 2015.978	32 29	γ Ari	TK2 TK2
STF 299	02433+0314	299.1	2.03	2015.978	26	γ Ceti	TK2
SHJ 49	04590+1433	305.6	39.32	2015.102	30		f
STF 627	05006+0337	260	21.2	2015.102	35		f
STF 652	05118+0102	179.8	1.6	2015.126	31		TK2
STF 696	05228+0333	29.1	32	2015.129	36	23 Ori	f
STF 729 AB	05312+0318	26.9 26.6	1.85 1.85	2015.115 2015.126	45 30	33 Ori	TK2 TK2
STFA 14AC	05320-0018	0.4	51.75	2015.129	17	δ Ori	f
STF 738 AB	05351+0956	44.2	4.18	2015.115	45	λ Ori	TK2
STF 762 AD	05387-0236	84	13.13	2015.129	33	σ Ori	f
STF 762 AE	05387-0236	61.6	41.65	2015.129	41	σ Ori	f
STF 795	05480+0627	221 221.9	1.02 0.96	2015.126 2015.159	28 40	52 Ori	TK2 TK2
STF 855 AB	06090+0230	114.1	29.27	2015.129	43		f
SHJ 70 AB	06278+2047	202.2 202.1	24.78 24.8	2015.187 2015.189	36 44	15 Gem	f
STTA 77	06290+2013	329.9	112.76	2015.167	10	ν Gem	f
STF 924	06323+1747	211	19.86	2015.187	51	20 Gem	f
STF 1066	07201+2159	229.7 228.5 228.1 228.3	5.6 5.6 5.7 5.7	2015.189 2015.198 2015.206 2015.209	35 36 41 26	δ Gem	f f f f
STF 1090 AB	07265+1831	98.2	60.7	2015.189	42		f
STF 1108	07328+2253	178.7	11.6	2015.198	33		f
STF 1110 AB	07346+3153	54.8 54.4	4.91 4.9	2015.137 2015.159	92 73	α Gem	TK2 TK2
STF 1196 AB	08122+1739	22.3 27.3 18.7 20.9 20.7 24.7	1.04 0.99 0.99 1.03 1.09 1.05	2015.222 2015.258 2015.261 2015.263 2015.269 2015.282	87 82 64 137 121 43	ζ Cnc	TK2 TK2 TK2 TK2 TK2 TK2
STF 1196 AC	08122+1739	61.9 62.5 62.5 62 62 61.8	6.24 6.25 6.15 6.14 6.15 6.17	2015.222 2015.258 2015.261 2015.263 2015.269 2015.282	81 55 65 130 119 40	ζ Cnc	TK2 TK2 TK2 TK2 TK2 TK2
STF 1224	08267+2432	51.5	5.54	2015.222	34	24 Cnc	TK2
ENG 37	08401+2000	151.8	149.6	2015.181	34	39 Cnc	f
S 574	08405+1933	249.9	133.97	2015.181	30	ε Cnc	f
STF 1338 AB	09219+3811	311.8 309.4	0.97 0.96	2015.263 2015.269	59 65		TK2 TK2

Table 1 continues on next page.

Double Star Observations with a 150mm Refractor in 2015

Table 1 (continued). Double Star Measurements in 2015

Designation	WDS ident	θ	ρ	Date	No	Name	Notes
STF 1369 AB	09354+3958	149.4 149.4	24.94 24.98	2015.299 2015.302	30 35		f f
STF 1369 AC	09354+3958	322.4 322.5	116.57 116.64	2015.299 2015.302	35 38		f f
STT 215	10163+1744	175.7 176.1	1.42 1.45	2015.293 2015.303	37 80		TK2 TK2
STF1424 AB	10200+1950	126.2 126.2	4.58 4.6	2015.222 2015.258	45 67	γ Leo	TK2 TK2
STF 1450	10350+0839	158.4 155.9 157.8	2 2.03 2.05	2015.285 2015.288 2015.293	28 34 38	49 Leo	TK2 TK2 TK2
S 612	10459+3041	173.5 173.6	196.15 196.18	2015.288 2015.291	36 36	42 LMi	f f
STF1540 AB	11268+0301	149.6	28.26	2015.272	47	83 Leo	f
STF1523 AB	1118+3132	174.9 176	1.67 1.71	2015.282 2015.285	71 68	ξ Uma	TK2 TK2
STF1565	11396+1900	304.4	21.71	2015.310	29		f
STF1670	12417-0127	4.8 6.8 4.8	2.35 2.25 2.32	2015.307 2015.310 2015.332	44 49 49	γ Vir	TK2; NC TK2 TK2
STF 1768 AB	13375+3618	95.9 94.4 94.5	1.69 1.68 1.68	2015.343 2015.346 2015.362	59 63 65	25 CVn	TK2 TK2 TK2
STF 1821	14135+5147	235.5	13.71	2015.433	42	κ Boo	f
STFA 26	14162+5122	32.6 32.6	38.93 38.88	2015.436 2014.439	45 45	ι Boo	f f
STF 1825	14165+2007	153.6 153.8	4.39 4.39	2015.441 2015.444	44 34		f f
STF 1850	14286+2817	261.2 261.1	25.43 25.42	2015.441 2015.444	36 36		f f
STF 1864AB	14407+1625	112.2 111.5	5.34 5.34	2015.384 2015.395	45 29	π Boo	TK2 TK2
STF 1884	14484+2422	55.7 55.1	2.13 2.1	2015.433 2015.436	18 36		TK2 TK2
STF 1888 AB	14514+1906	302.6 303.4 302.6	5.50 5.53 5.49	2015.374 2015.384 2015.395	40 18 29	ξ Boo	TK2 TK2 TK2
STT 288	14534+1542	159.5 159.9 160.6 160.2	0.96 0.89 0.93 1.08	2015.374 2015.384 2015.395 2015.425	35 17 40 23		TK2 TK2 TK2 TK2
STF 1909	15038+4739	69 68.9	0.84 0.88	2015.365 2015.37	100 61	44 Boo	TK2 TK2
STF 1931 AB	15187+1026	166.3	13.35	2015.430	37		f
STF 1938	15245+3723	3.8 5.1 3.9	2.18 2.2 2.19	2015.4 2015.411 2015.425	61 28 63	μ Boo	TK2 TK2 TK2

Table 1 continues on next page.

Double Star Observations with a 150mm Refractor in 2015

Table 1 (conclusion). Double Star Measurements in 2015

Designation	WDS ident	θ	ρ	Date	No	Name	Notes
STF 1954 AB	15348+1032	172.1	3.9	2015.430	75	δ Ser	TK2
STF 2010 AB	16081+1703	13.2	27	2015.524	39	κ Her	f
STF 2032 AB	16147+3352	238.5	6.98	2015.450	40	σ CrB	TK2
		238.4	6.99	2015.455	48		TK2
STF 2118 AB	16564+6502	64.7	0.94	2015.450	60	20 Dra	TK2
		66.4	0.95	2015.455	28		TK2
STF 2130 AB	17053+5428	2.7	2.42	2015.496	50	μ Dra	TK2
		2.5	2.42	2015.499	61		TK2
STF 2140	17146+1423	103.8	4.63	2015.543	45	α Her	TK2
		103.4	4.65	2015.545	45		TK2
STF 2161AB	17237+3709	320.2	3.94	2015.554	51	ρ Her	TK2
		320.3	3.99	2015.556	36		TK2
STF 2272 AB	18055+0230	125.3	6.15	2015.515	90	70 Oph	TK2
		125.5	6.18	2015.521	33		TK2
STF 2289	18101+1629	222.2	1.19	2015.521	41		TK2
		224	1.19	2015.543	50		TK2
		221.7	1.15	2015.554	39		TK2
STT 358AB	18359+1659	148.8	1.63	2015.573	20		TK2
		148.4	1.60	2015.575	19		TK2
		149.1	1.5	2015.595	39		TK2
STF 37 AB	18443+3940	172.1	208.73	2015.513	11	ε & 5 Lyr	f
STF 2382 AB	18443+3940	345.8	2.13	2015.502	33	ε Lyr	TK2
		346.4	2.21	2015.513	38		TK2
STF 2383 CD	18443+3940	76.6	2.27	2015.502	29	5 Lyr	TK2
		76.2	2.3	2015.513	38		TK2
STF 2579 AB	19450+4508	215.5	2.21	2015.636	59	δ Cyg	TK2
		217.8	2.62	2015.641	23		TK2
		217.1	2.65	2015.568	71		TK2
		217.7	2.6	2015.74	57		TK1.4; A
STF 2583 AB	1948+1149	102.3	1.33	2015.581	66	π Aql	TK2
		103.1	1.32	2015.586	66		TK2
		102.4	1.37	2015.597	125		TK2
STF 2737AB - C	20591+0418	67.3	10.29	2015.822	32	ε Equ	TK2
STF 2758 AB	21069+3845	152.4	31.6	2015.742	71	61 Cyg	f; A
		152.4	31.59	2015.748	13		f; A
S 799 AB	21434+3817	60.2	149.47	2015.742	14	79 Cyg	f; A
STF 2822 AB	21441+2845	319.1	1.6	2015.568	74	μ Cyg	TK2
		318	1.52	2015.707	40		f; A
		318	1.62	2015.74	77		TK1.4; A
		318.8	1.56	2015.748	38		TK1.4; A
STF 2909	22288-0001	163.8	2.3	2015.819	80	ζ Aqr	TK1,4; A
		163.5	2.23	2015.822	39		TK2

Double Star Observations with a 150mm Refractor in 2015

Table 2. Residuals for Double Stars in 2015

Designation	WDS ident	Date	No	θ	ρ	Δθ	Δρ	Ref.	Notes
STF 060 AB	00491+5749	2015.8	2	324.5	13.27	0.5	-0.10	Str1969a	
STF1066	07201+2159	2015.2	4	228.6	5.64	0.4	0.14	Hop1960a	
STF1110 AB	07346+3153	2015.1	2	54.6	4.91	0.2 0.5	-0.15 -0.1	Hei1988a Doc1985c	
STF1196 AB	08122+1739	2015.3	6	22.1	1.04	4.1 3	-0.09 -0.08	Sod1999 WSI2006B	1
STF1338 AB	09219+3811	2015.3	2	310.5	0.96	-3	-0.04	Sca2002b	2
STT 215	10163+1744	2015.3	2	176	1.44	-2.4	-0.12	Zae 1984	3
STF1424 AB	10200+1950	2015.2	2	126.2	4.59	0.1	0.12	Rab1958	
STF1523 AB	1118+3132	2015.3	2	175.4	1.69	0.2	-0.11	Msn1995	
STF1670	12417-0127	2015.3	3	5.5	2.31	0.2 2.2	0 -0.05	Sca2007c Sod1999	
STF1768 AB	13375+3618	2015.4	3	94.9	1.68	-0.1	-0.01	Sod1999	
STF1888 AB	14514+1906	2015.4	3	302.8	5.5	0.4	-0.11	Sod1999	
STT 288	14534+1542	2015.4	4	160.1	0.96	1.6	-0.05	Hei1998	
STF1909	15038+4739	2015.4	2	69	0.86	0.8 1.6	0.03 -0.15	Sod1999 Zir2011	4
STF1938	15245+3723	2015.4	2	4.1	2.19	0.4 0.7	-0.03 -0.05	Sca2013a Sod1999	
STF2032 AB	16147+3352	2015.5	2	238.4	6.99	0.1 0.1	-0.2 -0.3	Rag2009 Sca1979	
STF2118 AB	16564+6502	2015.5	2	65.2	0.94	-1.6	-0.21	Sca2002d	
STF2130 AB	17053+5428	2015.5	2	2.6	2.42	0.1	-0.09	Pru2012	
STF2272 AB	18055+0230	2015.5	2	125.4	6.16	-0.5	-0.19	Pbx2000b	
STF2289	18101+1629	2015.5	3	222.7	1.18	6.9	-0.06	Hop1964b	5
STT358AB	18359+1659	2015.6	3	148.9	1.56	2.7	0.06	Hei1995	6
STF2382	18443+3940	2015.5	2	346.1	2.17	0.2 0.2 0	-0.1 -0.17 -0.31	Nov2006e WSI2004b Gzl1956a	
STF2383	18443+3940	2015.5	2	76.4	2.29	0.4	-0.1	Doc1984b	
STF2579 AB	19450+4508	2015.6	4	216.9	2.51	-0.3	-0.22	Sca2012c	
STF2758 AB	21069+3845	2015.7	2	152.4	31.6	0.4 -0.2	0 -0.06	Pko2006b Kis1997	
STF2822 AB	21441+2845	2015.7	4	318.5	1.59	-3.3	0.05	Hei1995	7
STF2909	22288-0001	2015.8	2	163.7	2.28	-0.2 -1.2	0.02 -0,11	Sca2010c Hei1984c	

Notes to Table 2

1. Measurements for previous years in (Maiwald, 2014, p. 107). (Argyle, 2015, p.4) gives Δθ +1,6 and Δρ +0,03 for 2014.222 against the 2006 orbit.
2. My own measurements for previous years in (Maiwald, 2014, p. 191) and (Maiwald, 2015, p.106). (Courtot, 2015, p. 11): Δθ –5,2 and Δρ +0,09 for 2014,290. Δθ always negative.
3. (Maiwald, 2014, p.190): Δθ –2,4 and Δρ –0,13 for 2013,3. (Argyle, 2012, p.4): Δθ –2,1 and Δρ –0,08 for 2011.360.
4. I was very surprised that this star could be measured with my telescope. Obviously the seeing was very good at these two evenings. My measurements for 2009 to 2014 in (Maiwald, 2014, p.191) and (Maiwald, 2015, p.106).
5. Star is known for deviation from ephemeris. See (Maiwald, 2014, p.190) and (Maiwald, 2015, p. 106) for my measurements from 2013 and 2014.
6. My own measurements show positive residuals in θ from 2012.6 to 2014.5. (Courtot, 2015, p.11): Δθ +1,4 for 2014.694; (Argyle, 2013, p.4): Δθ +4,4 for 2012,683.
7. Star is known for deviation from ephemeris. Residuals in θ always negative.

Double Star Measurements Using a Webcam and DSLR, Annual Report of 2015

Joerg S. Schlimmer

Seeheim-Jugenheim, Germany
js@epsilon-lyrae.de

Abstract: This paper reports 149 double star measurements from 2015; minimum separation is 0.58 as (eta CrB), maximum separation is 447 as (BUP 153AC). The mean value of all measurements is 37.5 as.

Report

This is a report of 149 double star measurements from 2015 made with a 12-inch Newtonian telescope, a standard webcam, and in some cases also with a DSLR camera. The closest binary which could be measured was η Coronae Borealis with a separation of 0.58 as, the maximum separation measured was on BUP 153AC at 447 as. The mean value of all the measurements is 37.5 as. Figure 1 gives a more details about the statistics.

Measurements were done with a 12-inch Newtonian telescope. This telescope has been used since 2012. A detailed description of the optical setup is given in annual report of 2012 (Schlimmer, 2013). Reproduction scales are about 0.77 as/pixel in primary focus, 0.34 as/pixel with a 2X barlow lens, 0.14 as/pixel with a 5X barlow lens for webcam measurements, and 0.70 as/pixel for DSLR images. In the case of DSLR imaging, an additional coma corrector was used. In all cases the data analyses were done with REDUC software (Florent Losse).

The focus of observations in the first half of 2015 was stars in Max Wolf's "Catalog About 1053 High Proper Motion Fix Stars" (Wolf, 1919), which are already listed in Simbad Database as well as in WDS catalog. This observational project was started in 2014 (Schlimmer, 2014).

In the second half of 2015, observations of close double stars gained more priority. The intention was to find out the limit of the observation site and instrumental conditions. Because the observation site is located

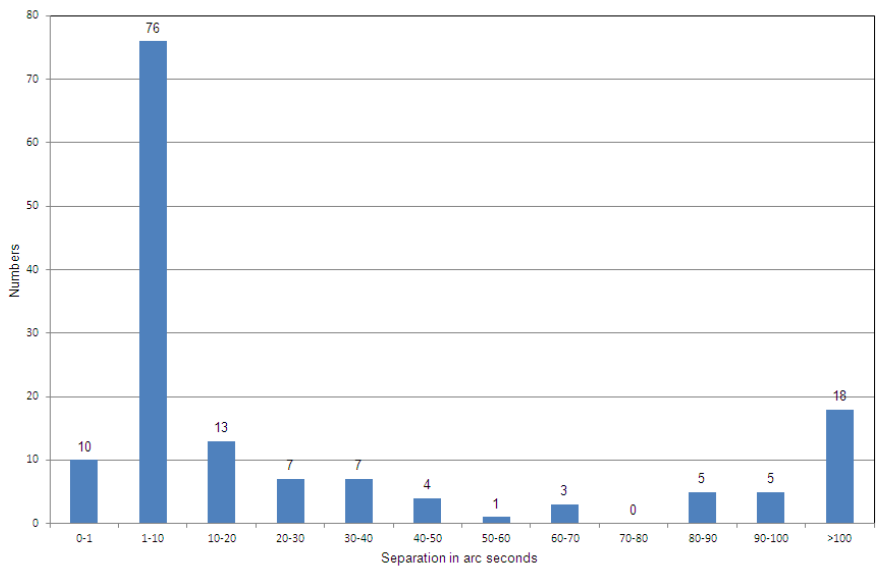

Figure 1. Number of measured double stars in dependence of separation interval

Figure 2. optical pair HIP56079 and N6IN008392, Canon 1100D, 120s 400ASA

Figure 3. STF2141AB with TYC 404-2150-1, webcam 15 of 50 best frames

in a suburban location in the Rhine River valley, seeing conditions are poor in comparison with seeing conditions in a rural site. Sometimes observations of double stars with separation smaller than 1 as could be made.

During the observations, a nice optical pair was noted; HIP56079 and N6IN008392 (11297+0736) which has a separation of about 17.9 as and a position angle of 283°. See Figure 2. The difference in brightness is more than 6 magnitudes. The proper motion of HIP56079 is -4.72 mas/y in R.A. and -26.61 mas/y in declination. N6IN008392 is only a background star with unknown proper motion.

STF2141AB is also an optical pair with separation of about 39.8 as. In a distance of 49.8 as a further optical component (TYC 404-2150-1) with brightness of 11.03 can be found [SIMBAD Catalog]. Only the A component has a significant proper motion in the direction away from B component. So, in the future distance between AB will increase while distance between A and TYC 404-2150-1 will decrease.

The following table shows my measurements of separation and position angle of 149 components from 2015. Brightness and coordinates are from Washington Double Star catalog (Mason, B.D., Wycoff, G.L. and Hartkopf) except brightness of HIP56079, N6IN008392 and TYC 404-2150-1 (SIMBAD Catalog).

Acknowledgements

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

This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France

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Double Star Measurements from 2015

NAME	RA+DEC	MAGS	PA	SEP	DATE	N	NOTES
BU 860	00000+3852	6.6; 11.4	107.6	6.56	2015.933	1	W
A 800	00029+4715	8.94; 9.10	119.4	1.51	2015.985	1	W
STT 514AB	00046+4206	6.16; 9.65	170.1	5.14	2015.933	1	W
A 910	00302+4557	8.7; 10.2	35.7	2.42	2015.985	1	W
HZG 1	00523+3930	8.3; 10.28	27.8	7.99	2015.126	1	W, Wolf 35
BU 235Aa;Ab	01106+5101	7.54; 7.82	137.3	0.81	2015.985	1	W
STF 162AB	01493+4754	6.47; 7.22	198.5	1.84	2015.985	1	W
STF 162AC	01493+4754	6.47; 9.24	179.2	20.81	2015.985	1	W
STF 314AB;C	02529+5300	6.95; 7.26	317.2	1.60	2015.985	1	W
ES 2598	03289+4039	9.04; 11.3	311.7	11.59	2015.126	1	W, Wolf 170
STFA 7AB	03311+2744	7.41; 7.81	234.0	44.02	2015.101	1	W
SMR 60BC	03311+2744	7.81; 13.	359.8	12.22	2015.101	1	W
LDS9155AC	03321+4340	8.56; 13.09	137.7	14.77	2015.126	1	W, Wolf 182
ES 560	03332+4615	8.33; 11.29	144.2	9.47	2015.189	2	W, Wolf 186
BUP 45AC	03356+4253	7.45; 7.98	90.4	177.56	2015.191	1	W, Wolf 193
LDS9156AD	03356+4253	7.45; 13.76	283.9	81.47	2015.191	1	W, Wolf 191
BUP 45AC	03356+4253	7.45; 7.98	90.4	177.46	2015.191	1	W, Wolf 191
LDS9156AD	03356+4253	7.45; 13.76	283.9	81.47	2015.191	1	W, Wolf 193
STF 425AB	03401+3407	7.52; 7.60	59.1	1.91	2015.985	1	W
ENG 14AB	03438+4236	7.54; 11.03	293.5	93.25	2015.191	1	W
S 455AB	04422+2257	4.24; 7.02	214.0	62.52	2015.101	1	W
STF 644AB	05103+3718	6.96; 6.78	219.3	1.59	2015.985	1	W
STFA 14AC	05320-0018	2.41; 6.83	0.4	52.15	2015.101	1	W, Mintaka
STF 746AB	05353-0441	10.4; 10.7	218.7	13.9	2015.126	1	W
STF 788AB	05447+0350	7.61; 10.05	91.1	7.29	2015.126	1	W
STF 788AC	05447+0350	7.61; 10.37	148.9	35.99	2015.126	1	W
STF 789AB	05450+0400	6.13; 10.17	149.8	13.78	2015.126	1	W
LDS6195AB	06032+1922	9.3; 13.5	229.4	7.31	2015.191	1	W, Wolf 262
STF1110AB	07346+3153	1.93; 2.97	54.4	5.01	2015.186	1	W, Castor
STF1135AB	07475+3325	5.14; 11.4	214.9	18.95	2015.186	1	W, π Gem
STF1135AC	07475+3325	5.32; 11.18	343.7	91.81	2015.186	1	W
STF1196AB	08122+1739	5.30; 6.25	26.7	1.11	2015.298	1	W, ζ Cnc
STF1196AC	08122+1739	5.30; 5.85	63.7	6.28	2015.298	1	W, ζ Cnc
ENG 38AB	08433+2128	4.65; 10.20	66.6	115.86	2015.284	1	W, γ Cnc
HJ 457AB	08447+1809	3.94; 12.2	71.9	40.61	2015.284	1	W, δ Cnc
HJ 110	08585+1151	4.25; 11.8	322.7	9.90	2015.284	1	W, α Cnc
STF1300AB	09013+1516	9.47; 9.73	178.3	5.07	2015.284	1	W
HJ 466AC	09320+2003	8.59; 12.48	75.5	37.45	2015.284	1	W, 6 Leo
H 6 76AB	09412+0954	3.56; 10.83	48.2	96.15	2015.284	1	W, ο Leo
STFB 6AB	10084+1158	1.40; 8.24	307.9	175.68	2015.253	2	D, W Regulus
HDO 127AD	10084+1158	1.40; 12.10	274.3	195.30	2015.253	2	D, W
WLF 1AB	11285+0750	10.34; 10.51	334.4	112.08	2015.309	1	D, Wolf 397
New	11297+0736	6.73; 12.84	283.0	17.87	2015.309	1	D, HIP56079
LDS4152	11523+0957	7.71; 15.70	348.9	229.95	2015.309	1	D, Wolf 1422

Table continues on next page.

Double Star Measurements Using a Webcam and DSLR, Annual Report of 2015

Double Star Measurements from 2015 (continued)

NAME	RA+DEC	MAGS	PA	SEP	DATE	N	NOTES
LDS 930AB	12089+2147	9.45; 14.63	39.3	15.48	2015.309	1	D, Wolf 1432
STF1782	13451+1822	7.98; 9.81	185.8	29.69	2015.457	1	W
BUP 153AC	13451+1747	10.01; 9.49	106.7	446.89	2015.479	1	W, Wolf 497
STF1863	14380+5135	7.71; 7.80	56.8	0.66	2015.520	1	W
STF1864AB	14407+1625	4.88; 5.79	111.7	5.47	2015.457	1	W, 29 Boo
STF1909	15038+4739	5.20; 6.10	68.2	0.90	2015.510	4	W, 44 Boo
SMR 32AB	15151+3318	12.76; 11.21	333.7	25.92	2015.449	1	W
SMR 32AC	15151+3318	12.76; 12.90	72.8	35.83	2015.449	1	W
SMR 32BC	15151+3318	11.21; 12.90	105.4	47.44	2015.449	1	W
STFA 27AB	15155+3319	3.56; 7.89	78.1	104.73	2015.449	1	W, del Boo
STF1932AB	15183+2650	7.32; 7.41	265.0	1.55	2015.487	1	W
STF1937AB	15232+3017	5.64; 5.95	208.3	0.58	2015.544	3	W, η CrB
STT 296AB	15264+4400	7.83; 9.09	275.6	2.16	2015.487	1	W
STF1950	15300+2530	8.07; 9.23	91.4	3.29	2015.487	1	W
STF1955AB	15339+2643	9.84; 10.32	237.0	7.69	2015.449	1	W
STF1954AB	15348+1032	4.17; 5.16	171.8	3.91	2015.487	2	W, δ Ser
STT 298AB	15360+3948	7.16; 8.44	185.7	1.12	2015.512	1	W
STF1992AB;C	16003+1140	9.46; 9.72	325.8	5.91	2015.522	1	W
STF2006AB	16003+5856	8.48; 9.96	181.3	1.42	2015.498	1	W
STT 303AB	16009+1316	7.69; 8.06	174.4	1.36	2015.498	2	W
FOX 193	16016+1024	10.84; 11.50	17.8	10.89	2015.522	1	W
STF2000	16030+1359	8.42; 9.22	226.7	2.50	2015.498	1	W
BU 811AB	16052+2211	8.71; 11.84	217.8	3.61	2015.522	1	W
STF2014AB	16086+4003	8.62; 10.41	91.4	8.31	2015.522	1	W
STF2015AB	16089+4521	8.24; 9.52	160.0	2.89	2015.405	2	W
STT 307	16105+4748	7.67; 10.71	201.4	17.50	2015.498	1	W
STT 305AB	16117+3321	6.44; 10.17	264.9	5.78	2015.512	1	W
STF2016	16121+1155	8.49; 9.60	148.2	7.36	2015.512	1	W
ES 1793	16126+5748	8.74; 11.52	55.8	5.65	2015.522	1	W
STF2030	16128+4122	7.91; 10.16	240.4	5.72	2015.539	1	W
STF2021AB	16133+1332	7.43; 7.48	359.1	3.86	2015.539	1	W
STF2029	16138+2844	7.95; 9.62	187.4	6.12	2015.539	1	W
ES 1088AB	16139+4736	8.32; 11.87	316.1	33.04	2015.498	1	W
STF2045	16203+6130	8.80; 10.18	184.1	1.85	2015.512	1	W
STF2047	16231+4738	8.54; 8.65	326.3	1.78	2015.512	1	W
STF2054AB	16238+6142	6.15; 7.09	350.5	0.92	2015.512	1	W
STF2052AB	16289+1825	7.69; 7.91	119.3	2.39	2015.512	1	W
STT 312AB	16240+6131	2.8; 8.2	142.8	4.38	2015.520	1	W
A 25	16240+2024	8.28; 10.8	114.6	5.40	2015.539	1	W
A 1860	16299+1424	8.9; 10.8	83.4	3.24	2015.512	1	W
STT 313	16326+4007	7.97; 8.31	128.9	0.90	2015.553	1	W
STF2072	16355+4741	9.80; 10.59	179.0	4.94	2015.553	1	W
STF2078AB	16362+5255	5.38; 6.42	104.9	3.07	2015.498	2	W
STFA 30AC	16362+5255	5.38; 5.50	193.3	89.93	2015.498	2	W

Table continues on next page.

Double Star Measurements Using a Webcam and DSLR, Annual Report of 2015

Double Star Measurements from 2015 (continued)

NAME	RA+DEC	MAGS	PA	SEP	DATE	N	NOTES
STF2089	16433+2508	8.66; 9.96	61.7	2.51	2015.520	1	W
STF2094AB	16442+2331	7.48; 7.87	74.2	1.09	2015.553	1	W
STF2107AB	16518+2840	6.90; 8.50	104.9	1.40	2015.553	1	W
STF2130AB	17053+5428	5.66; 5.69	3.2	2.52	2015.520	1	W
LDS 989	17165+0413	12.61; 13.08	318.1	20.15	2015.596	1	W
STF2141AB	17166+0325	8.32; 10.72	122.9	39.75	2015.596	1	W
New AC		8.32; 11.5	325.3	49.80	2015.596	1	W
STF2185AB	17348+0601	7.46; 10.32	4.7	27.19	2015.596	1	W
STF2185AC	17348+0601	7.46; 8.43	253.6	92.80	2015.596	1	W, Wolf 760
STF2203	17412+4139	7.72; 7.81	291.5	0.73	2015.553	1	W
STT 339	17561+2130	8.37; 10.76	170.7	4.05	2015.660	1	W
HO 423	17575+2759	8.95; 11.47	292.1	4.73	2015.660	1	W
ALL 2	17578+2751	8.86; 9.93	206.2	18.92	2015.660	1	W
STF2254AB	17590+1226	9.11; 9.31	267.0	3.58	2015.660	1	W
A 1886	18000+5316	9.4; 10.5	340.1	4.73	2015.665	1	W
STF2271AB	18003+5251	8.17; 9.24	269.7	3.65	2015.665	1	W
STF2277AB	18031+4828	6.25; 8.93	127.5	26.68	2015.596	1	W
STF2277AC	18031+4828	6.25; 10.19	297.2	99.72	2015.596	1	W, Wolf 1405
H 5 39AB	18369+3846	0.09; 9.5	184.4	82.26	2015.596	1	W, Vega
STFB 9AE	18369+3846	0.09; 9.5	39.3	86.36	2015.596	1	W
STF2382AB	18443+3940	5.15; 6.10	346.0	2.23	2015.665	1	W, ε Lyr
STF2383CD	18443+3940	5.25; 5.38	76.4	2.37	2015.665	1	W, ε Lyr
BU 137AB	18540+3723	8.69; 9.02	168.6	1.52	2015.665	1	W
AG 366	18581+4711	8.54; 8.67	190.3	1.39	2015.665	1	W
STF2448	19037+3545	8.75; 8.80	191.3	2.41	2015.665	1	W
STF2466AB	19079+2948	8.57; 9.02	104.0	2.37	2015.665	1	W
STFB 10AB	19508+0852	0.95; 9.82	285.8	195.83	2015.596	1	W, Altair
STFB 10AC	19508+0852	0.95; 10.3	109.5	186.35	2015.596	1	W, Altair
DAL 27AD	19508+0852	0.95; 11.9	104.9	26.83	2015.596	1	W, Altair
SMR 5AE	19508+0852	0.95; 11.0	354.2	151.34	2015.596	1	W, Altair
SMR 5AF	19508+0852	0.95; 10.3	47.8	292.41	2015.596	1	W, Altair
SMR 7	20000+1736	10.1; 11.4	264.0	4.08	2015.747	1	W
STF2619AB	20011+4816	8.91; 8.92	237.3	4.15	2015.777	1	W
HJ 1495AB	20136+4644	3.93; 13.4	327.6	36.46	2015.777	1	W, 30 Cyg
STFA 50AC	20136+4644	3.93; 6.97	173.3	106.79	2015.777	1	W
BU 1483CI	20136+4644	6.97; 12.26	136.2	60.24	2015.777	1	W
SMR 68HK	20136+4644	12.6;	261.7	8.90	2015.777	1	W
SMR 69	20139+4642	12.9; 13.	62.4	7.01	2015.777	1	W
STF2655AB	20141+2213	7.89; 7.95	3.2	6.14	2015.777	1	W
STF2655AC	20141+2213	7.89; 10.09	154.9	60.85	2015.777	1	W
ES 27	20143+4648	10.58; 10.61	338.8	3.76	2015.777	1	W
STT 403AB	20144+4206	7.31; 7.64	171.6	0.92	2015.695	1	W
STF2657AC	20144+4206	7.28; 9.80	31.5	11.60	2015.695	1	W
STT 410AB	20396+4035	6.73; 6.83	2.5	0.82	2015.695	1	W

Table concludes on next page.

Double Star Measurements from 2015 (conclusion)

NAME	RA+DEC	MAGS	PA	SEP	DATE	N	NOTES
STF2758AB	21069+3845	5.35; 6.10	152.3	31.55	2015.777	2	W, 61 Cyg
STF2758AG	21069+3845	5.35; 10.84	235.6	256.12	2015.777	1	W
STF2758AH	21069+3845	5.35; 10.89	270.7	108.08	2015.777	1	W
SMR 1AI	21069+3845	5.35; 10.74	240.7	17.54	2015.777	1	W
SMR 40AO	21069+3845	5.35; 12.65	282.6	154.94	2015.777	1	W
SMR 40AP	21069+3845	5.35; 12.84	292.3	148.65	2015.777	1	W
A 1479	23007+5513	8.46; 11.53	124.3	5.20	2015.925	1	W
STF2973	23028+4404	6.41; 10.14	38.8	7.45	2015.925	1	W
STF3000	23188+2513	9.63; 9.83	50.4	3.39	2015.933	1	W
STF3007AB	23228+2034	6.74; 9.78	94.3	5.70	2015.933	1	W
STF3026	23363+2854	9.42; 9.94	276.2	3.42	2015.933	1	W
STT 502	23399+6344	6.89; 10.64	226.2	3.63	2015.933	1	W
STT 503AB	23420+2018	8.26; 8.63	138.6	0.95	2015.933	1	W
STF3042	23519+3753	7.62; 7.75	87.4	5.76	2015.933	1	W
BU 728AB	23522+4331	8.69; 8.94	8.1	1.12	2015.933	1	W
AG 429	23527+2920	9.44; 10.36	270.3	6.33	2015.933	1	W
STF3050AB	23595+3343	6.46; 6.72	340.3	2.37	2015.933	1	W, Mayer 80

Table Notes

D: A DSLR was used for imaging.

W: A webcam was used for imaging.

New Companions to Double Star HJ 691 = WDS 05052+0914 = HD 240582

Wolfgang Vollman
Dammaeckergasse 28/D1/20, A-1210 Wien, Austria
vollman@gmax.at

Abstract: This paper has measurements of new companions to the double star HJ 691 in Orion. One of the new companions is close enough to suspect it is a physical binary.

While measuring the double star HJ 691 in Orion (see Table 1) with the currently known companion in WDS [1] labeled as C, an additional close companion labeled B was noted. Two other previously uncataloged companions labeled D and E were also measured.

At the time of writing (Feb.2016) the data (eg. proper motion) in the various catalogs accessible via the Vizier service [3] are not able to indicate if A-B is a physical or optical pair. For B there seems to be no catalog data available yet. The A-B pair is closer than the Aitken criterion [4], therefore we could suspect that it is a physical binary.

References

[1] The Washington Visual Double Star Catalog (Mason+ 2001-2014)

[2] Aladin service: http://aladin.u-strasbg.fr/.

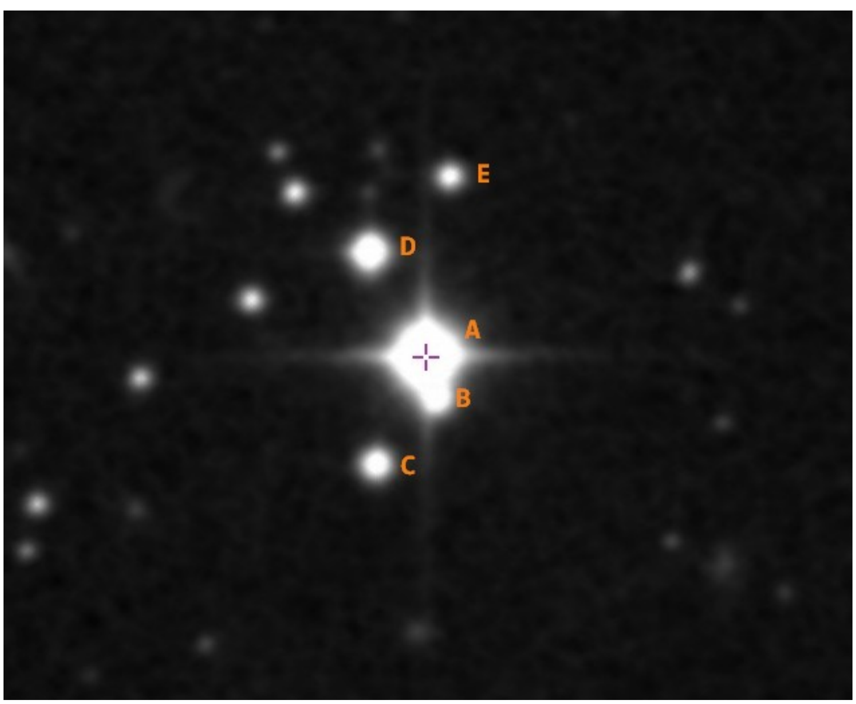

Figure 1. HJ 691 on Digital Sky Survey DSS2 blue image from Aladin service [2]. North is up.

New Companions to Double Star HJ 691 = WDS 05052+0914 = HD 240582

Table 1: Measures of HJ 691 components relative to A on 5 images taken with Newtonian reflector 0.25-m aperture f/4 with a CCD by Michael Jaeger of Austria. Images were taken on 2016 Jan 1.

Components	Green Magnitude (approximate)	Position angle [degrees]	Separation [arc seconds]
A	9.5		
A-B	11.8	199.5	7.5
A-C	12.0	155.4	23.1
A-D	11.7	29.1	23.7
A-E	12.8	352.1	36.5

Astrometric position of A = HD 240582 measured on the same images taken 2016 January 1 with UCAC4 reference stars: (2000.0): 5h 05m 14.28s ± 0.03s +9° 13' 49.3" ± 0.5"

[3] Vizier service: http://vizier.u-strasbg.fr/

[4] Francisco Rica Romero, 2006, "R.G. Aitken's Criterion to Detect Physical Pairs", *JDSO*, **2**, 36 - 41.

Acknowledgments

This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France

This research has made use of "Aladin sky atlas" developed at CDS, Strasbourg Observatory, France

This research has made use of the VizieR catalog access tool, CDS, Strasbourg, France

Mind the Gap – Jonckheere Double Stars Not Listed in the WDS

John Nanson
Star Splitters Double Star Blog
Manzanita, Oregon
jnanson@nehalemtel.net

Wilfried R.A. Knapp
Vienna, Austria
wilfried.knapp@gmail.com

Abstract: We describe our efforts to determine the cross-referenced identifications of a large group of Robert Jonckheere's double stars which failed to turn up in a search of the WDS catalog sorted by discoverer ID.

Report

During a review of the 3350 objects in Robert Jonckheere's 1962 Double Star Catalog (*Catalogue Général de 3350 étoiles doubles de faible éclat observées de 1906 à 1962*), we came across a reference in Amosse 2012 (p. 5) which described J 3319 as misidentified. In the course of determining the identity of that star, we discovered a total of 393 J objects which are not listed in the Washington Double Star Catalog, which results in a large gap in Jonckheere's total catalog of double stars. We soon discovered the WDS Notes Files contains references to most of these objects. Many of them have been cross-referenced with other identifications which have replaced the Jonckheere number in the WDS, primarily because those stars were discovered by other observers prior to the date of Jonckheere's discovery. Consequently, we downloaded the WDS Notes File into an Excel spreadsheet and searched for each of the objects in order to identify them. In the case of those objects for which we couldn't find references in the WDS Notes File, we used the Stelle Doppie web site (http://stelledoppie.goaction.it/) as a back-up source, which resulted in a small number of identifications.

In the course of that search, questions arose on two stars, J 1391, and J 3101. J 1391 is addressed in Table 3 and J 3101 is discussed in the next section of this paper.

At the conclusion of our searches, we were left with a list of 50 Jonckheere objects for which data or designations failed to turn up. To determine the identity of those objects, we turned to the pages of Robert Jonckheere's 1962 Catalog. After locating each entry, we examined it to see what clues were provided, entered his 2000 coordinates into Aladin, overlaid WDS identifications on the image, and confirmed the identities of all but a few of the objects. That information and the supporting data will be presented in a later supplement to this paper. Those objects are identified in the following table with the comment "No data found."

Also included in the list below are 23 objects which are listed in the WDS with no coordinates because they could not be located at or near the coordinates reported by Jonckheere. Bill Hartkopf at the USNO/WDS, who has determined the identities of many of Jonckheere's lost objects, has so far been unable to match up any of the 23 pairs. None of them have been declared bogus objects up to this point. We have an effort underway now to see if we can find at least some of this group.

J 3101

It appears that Robert Jonckheere included J 3101 in his 1962 *Catalogue Général* solely because it's a red star. (He also included two other red stars in his catalog, J 2001 and J 2011). As the excerpt from his catalog in Figure 1 shows, no measurements were made of J 3101. The text in the catalog entry reads: "Red star of

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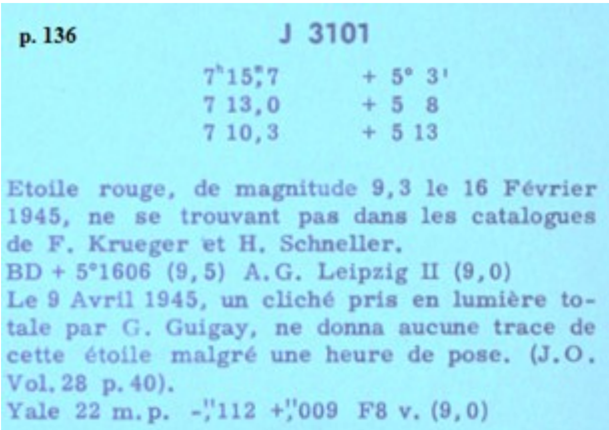
p. 136 J 3101

7h15m,7 + 5° 3'
7 13,0 + 5 8
7 10,3 + 5 13

Etoile rouge, de magnitude 9,3 le 16 Février 1945, ne se trouvant pas dans les catalogues de F. Krueger et H. Schneller.
BD + 5°1606 (9,5) A.G. Leipzig II (9,0)
Le 9 Avril 1945, un cliché pris en lumière totale par G. Guigay, ne donna aucune trace de cette étoile malgré une heure de pose. (J.O. Vol. 28 p. 40).
Yale 22 m.p. -",112 +",009 F8 v. (9,0)

Figure 1. Excerpt from Jonckheere's 1962 catalog.

magnitude 9.3, on February 16th, 1945, which is not included in the catalogues of F. Krueger and H. Schneller. BD +5 1606 (9,5), A.G. Leipzig II 9,0). On April 9, 1945, a photo taken in full light by G. Guigay showed no traces of this star despite a one hour exposure."

As Figure 2 shows, there are actually two stars at the location of J 3101, which raises the question of why Jonckheere didn't refer to the pair as a double star and measure it. Equally puzzling is the reference in his 1962 catalog to the red star not being visible in a 1945 photograph. A search for the 1945 image failed to turn up anything, but in the process we confirmed the red star is designated a variable star by the AAVSO (Figure 3.) However, adding to the mystery is the AAVSO magnitude range of 9.1 to 10.5, which would indicate

V	CCDM	rComp	Comp	Disc	dRAs	dDEs	theta	rho	Vmag	HIC	CooFlag	RAJ2000	DEJ2000
VizieR	07156+0503		A		2.57	-20.4			10.9	35119	0	108.9107	+05.0443
VizieR	07156+0503		B	J 3101					11.4	35119	3	108.9107	+05.0443

Figure 2. Aladin image showing Jonckheere's red star and the double star to the south of it. Neither J 3101 nor the white pair south of it was listed in the WDS when we began this paper. The red star is the one Jonckheere identified as J 3101, while the CCDM catalog refers to the white pair as CCDM 07156+0503 and identifies it as J 3101

the star should have been visible in the 1945 photo.

Jonckheere also published an account of J 3101 in the March-April, 1945, issue of the Journal des Observateurs (Jonckheere 1945, p. 40) which went into more detail (Figure 4). In that short account, he describes J 3101 as a variable star, having found a magnitude of 9.5 for it in the Bonner Durchmusterung, as well as a magnitude for it of 9.0 in the A.G. Leipzig II catalog. He also refers to a Toulouse Observatory Carte du Ceil photographic plate of January 23rd, 1906, on which the red star is not visible, which we were also unable to locate.

Using the Strasbourg Astronomical Data Centre's CDS Portal, we found images from 1954, 1991, and 1997 showing not only the brighter of the red pair, but the fainter one as well (Figure 5). In addition, Wilfried Knapp imaged the star using a remote telescope (Figure 6), which clearly showed two stars at the location.

In Jonckheere's account of J 3101 in Figure 4, after referring to the Carte du Ciel plate, the next to last sentence reads: "Therefore the red star probably has a color index higher than +4." Bill Hartkopf pointed us toward Simbad's data on the star where we found a B value of 13.55 and a V value of 9.21, resulting in a color index of 4.34, which confirms Jonckheere was on the right track with his +4 CI estimate. Simbad also shows a spectral classification of N for the star. Bill Hartkopf mentioned the plates in use for both 1906 Carte du Ceil and 1945 images were blue sensitive and had very poor response in the red, thus explaining the absence for the red J 3101 from those images.

To some degree, that could explain why Jonckheere

Figure 3. AAVSO designation for the red star referred to by Jonckheere in his 1962 catalog entry for J 3101.

didn't mention or refer to the faint secondary located 9" from the primary. On page three of his 1962 catalog he lists the various telescopes he used during his career, along with the dates he used them. According to that list, when he made his 1945 observation of J 3101 he

Une Nouvelle Etoile Rouge (J 3101)

Par M. Robert Jonckheere

Au cours de nos recherches d'étoiles doubles nouvelles, nous avons trouvé, le 16 février 1945, une étoile rouge, de magnitude 9,3, qui ne figure pas dans le *Neuer Katalog Farbiger Sterne*, de F. Krueger, ni, comme variable, dans le *Katalog Veränderlicher Sterne für 1943*, de H. Schneller.

Les coordonnées de cette étoile, pour 1950, sont :

$$\alpha = 7 \text{ h. } 13 \text{ m. } 0 \text{ s.} \qquad \delta = +5^\circ 9'1$$

Contrairement à la Rouge J 2001, qui ne se trouve dans aucun catalogue, malgré sa magnitude qui peut atteindre 8,3, cette nouvelle rouge est une étoile de la *Bonner Durchmusterung*. C'est la B.D. +5° 1606, pour laquelle Argelander donne la magnitude 9,5. Elle a, de plus, été notée, malgré le faible éclat indiqué dans le B.D., sous le n° 3661 de A.G. Leipzig II, qui lui assigne la magnitude 9,0. Cette étoile est donc variable.

Aucun de ces catalogues ne fait état de sa coloration. Son indice de couleur est cependan ttrès grand. Une pose d'une heure en lumière totale, faite le 9 avril 1945 par M. G. Guigay, avec l'objectif Dogmar Goerzde 18 cm. de l'Observatoire de Marseille, ne donne aucune trace de cette étoile sur la plaque. Elle n'est pas visible non plus sur le cliché + 5° n° 54, du 23 janvier 1906, de la Carte photographique du Ciel de l'Observatoire de Toulouse. Cette étoile rouge a par conséquent un indice de couleur probablement supérieur à +4. C'est pour cette raison que nous nous y sommes arrêté.

(*Observatoire de Marseille*).

Figure 4. Jonckheere's 1945 Journal des Observateurs account of J 3101.

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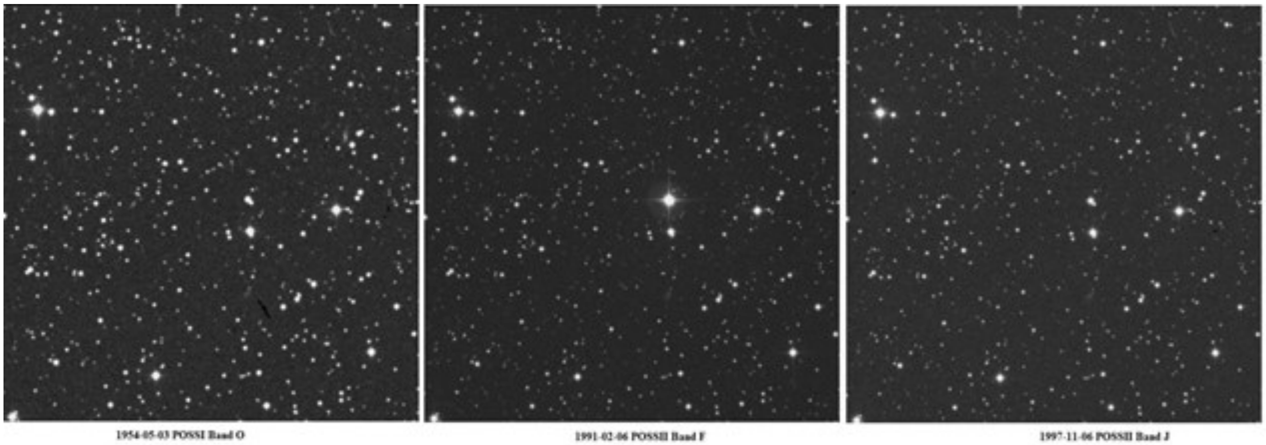

Figure 5. 1954, 1991, and 1997 images of J 3101 and the white pair to the south of it.

was using the 80cm (31.5 inch) telescope at Marseille, which Thorel (2005, p. 30) estimates has a 15.8 magnitude limit. Our research shows the secondary with a magnitude of 15.0 (see Table 1), which would seem to put it within visual reach despite the five magnitudes of difference between the two stars. Also contributing to the mystery is Jonckheere's acute vision, which is also well documented by Thorel (2001, pp 3-4 and 5) and was mentioned by Jonckheere himself on page 5 of his 1962 catalog.

At any rate, we found ourselves with a situation in which two historically significant pairs were not listed in the WDS catalog: J 3101 and the white pair to its south. Bill Hartkopf confirmed our guess that J 3101 was left out of the WDS because Jonckheere didn't provide measures for it. Adding somewhat to the confusion is the CCDM catalog's reference to the pair of white stars to the south of the red pair as J 3101 (see the data box below Figure 2).

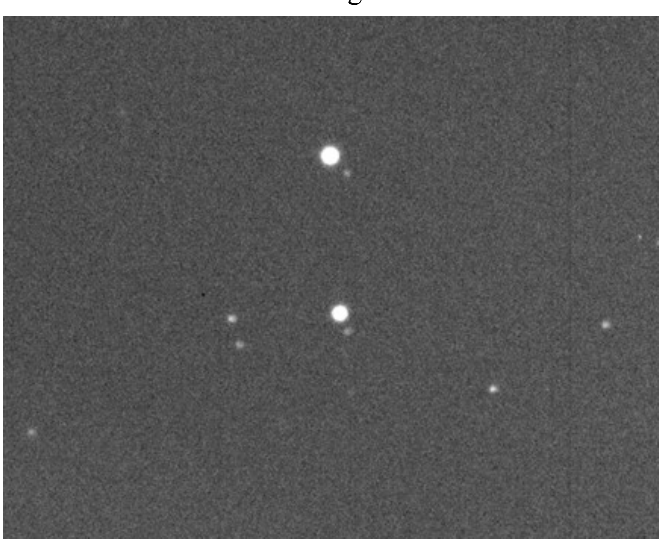

Figure 6. iT27 Image by Wilfried Knapp (stack of 10 images with 2s exposure time). J3101 is the northernmost pair in the image, DOM 2 is south of it. North is at the top, east at the left.

We asked Bill about the possibility of having both the red and the white pair added to the WDS because of their historical significance. After reviewing all the data, he added the white pair to the WDS with a designation of DOM 2 (DOM refers to Dommanget, the lead author of the CCDM). The red pair was added to the WDS with the designation J 3101. DOM 2 is now WDS 07156+0503 and J 3101 is 07156+0504.

With regard to the WDS data, initial coarse measurements for J 3101, based on a GSC2.3 image in Aladin, resulted in a separation of 9.3" and a PA of 227° and magnitudes of 9.90 and 15.5. For DOM 2, initial measures are 7.3" and 204.1° with magnitudes of 10.62 and 14.69, which are based on 1995 POSS plates. Our measures, which are shown in Tables 1 and 2, differ somewhat. It should be pointed out that we found the faint magnitudes of both secondaries made measures rather difficult.

Gaps in the Jonckheere Double Star Catalog

Searches have been run in the WDS Notes Files and Stelle Doppie on all the J Catalog numbers in Table 3. Those catalog numbers for which no data was found in those two sources are identified in the table with the comment "No data found"; those stars will appear in a later report once we've determined their identities. All of the stars in Table 3 which include the comment "Listed in WDS with no coordinates" are shown in Jonckheere's 1962 General Catalog. A search is under way now to locate these.

Acknowledgements:

Special thanks to Bill Hartkopf at the USNO/WDS

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Table 1. Measurements of J3101 with Astrometrica

	RA	Dec	Sep	Err Sep	PA	Err PA	Vmag	Err Vmag	Date
A	07 15 38.877	05 03 39.700	9.212	± 0.22	224.830	± 1.4	9.973	0.096	2016.049
B	07 15 38.442	05 03 33.167					15.000	0.113	

Table 2. Measurements of DOM 2 with Astrometrica

	RA	Dec	Sep	Err Sep	PA	Err PA	Vmag	Err Vmag	Date
A	07 15 38.644	05 02 40.910	7.435	± 0.22	204.666	± 1.7	10.732	0.096	2016.049
B	07 15 38.437	05 02 34.153					15.026	0.115	

As a countercheck for the quality of our measures, we used the URAT1 coordinates for DOM 2 (the secondary of J 3101 is not identified in URAT1), resulting in very similar values of 7.387” for separation and 204.88° for position angle.

for his invaluable assistance and insight which kept us from straying too far into nebulous territory.

We also want to thank Chris Thuemen for making a copy of Robert Jonckheere's 1962 *Catalogue Général de 3350 étoiles doubles de faible éclatobservées de 1906 à 1962* available to us, without which we would have been stumbling around in the dark.

The following tools and resources have been used for this research:

- Aladin Sky Atlas v8.0
- Astrometrica v4.8.2.405
- AstroPlanner v2.2
- CDS Portal
- iTelescope: iT27 - 700mm CDK with 4531mm focal length. CCD: FLI PL09000. Resolution 0.53 arcsec/pixel. V-filter. Located in Siding Spring, Australia. Elevation 1122m
- SIMBAD, VizieR
- Sky Tools 3
- Stelle Doppie Web Site (http://stelledoppie.goaction.it/)
- Washington Double Star Catalog

References:

Amossé, André; Razemon, Stéphane; Grase, Francis; Caille, Sébastien; Rousselle, Jean-Paul; Berthe, Michel – 2012, Mesures d’étoiles doubles visuelles du “Catalogue Jonckheere“ à l’Observatoire de Lille Campagne 2007-2012, Observations et Travaux, Vol. 81 No. 2, pp.2-8.

Buchheim, Robert – 2008, CCD Double-Star Measurements at Altimira Observatory in 2007, Journal of Double Star Observations, Vol. 4 No. 1 Page 28: Formulas for calculating separation and position angle from RA and Dec coordinates

Jonckheere, Robert, 1945. Journal des Observateurs, Vol 28 No. 3-4 (Mar-Apr 1945), p. 40.

Jonckheere, Robert, 1962. Catalogue Général de 3350 étoiles doubles de faible éclat observées de 1906 à 1962, Observatoire de Marseille and Journal des Observateurs, Place le Verrier, Marseille.

Thorel, Jean-Claude, 2001. Robert Jonckheere: Une vie de passion pour les étoiles doubles, Ceil et Terre: Bulletin de la Société belge d’astronomie, de météorologie et de physique de globe, Vol 117, No. 1 (2001), pp. 2-9

Thorel, Jean-Claude, 2005. Robert Jonckheere et les Étoiles Doubles: Qu’en est-il des mesures?, Observations & Travaux, Vol. 61 (2005), pp. 26-33

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Table 3. Comparison of Jonckheere Catalog with the WDS.

Jonck-heere Catalog Number	Designation for the J Number in the WDS Catalog	Notes and Comments	WDS Designations
61	STF 1043		STF 1043 is WDS 07126-0041
94	AG 358	AB is J 94	AG 358 is WDS 18067+1359
109	HJ 1352		HJ 1352 is WDS 18501+2949
123	BU 55		BU 55 is WDS 19463+1035
126	STF 2590 CD	WDS Note: "Also called J 126 ab, renamed STF 2590 CD by USNO 6/29/99."	STF 2590 is WDS 19523+1021
127	SEI 988		SEI 988 is WDS 20119+3510
128	ES 205	WDS Notes File: "SEI 1042. J 128."	ES 205 is WDS 20150+3500
132	BU 659		BU 659 is WDS 19547+0708
139	BU1471		BU 1471 is WDS 19385+1715
149	HU 341		HU 341 is WDS 19335+1814
175	J 135	WDS Notes file also states: "J 2190. OL 193"	J 135 is WDS 20157+1003
176	J 549		J 549 is WDS 20130+1029
177	BU 1051		BU 1051 is WDS 21131+1028
184		No data found	
219	A 2301		A 2301 is WDS 00254+2036
264	BRT 2120		BRT 2120 is WDS 06348+0819
320		Planetary Nebula which carries the J 320 designation.	
357	A 516		A 516 is WDS 07008-0656
477	AG 371		AG 371 is WDS 19041+1106
489		**Listed in WDS with no coordinates.**	J 489 is WDS 19437+0239
504	BRT 3354		BRT 3354 is WDS 20047+2443
533	BU 973 AD = J 533 AB; STF 2435 AC = J 533 AC; Howe 45 DC = J 533 BC. WDS Note: "Here AB is BU 973, STF 2435 = AC of J 533. AD = AB of J 533. DC = Howe 45 is BC of J 533.AB is the C component of 19022+0845STF2436."		BU 973/STF 2435/HWE 45 is WDS 19020+0846
571		**Listed in WDS with no coordinates. Coded "X", Dubious Double**	J 571 is WDS 20422+0724
585	A 2303		A 2303 is WDS 00419+1751
810		No data found	
866		BU 1338 CD	BU 1338 CD is WDS 00066+2901
880		BAR 23 AB and BC = J 880 AB and BC	BAR 23 is WDS 02065+5703
917		BU 844 BC	BU 844 is WDS 22296+0538
937		**Listed in WDS with no coordinates.**	J 937 is WDS 05403+3116
1012		STF 1518 AB and BC = J 1012 AB and BC	STF 1518 is 11145+0516
1028		CD pair of J 1027 is J 1028	J 1027 is 15086+0052
1060		**Listed in WDS with no coordinates.**	J 1060 is WDS 07212+0921

Table 3 continues on the next page.

Table 3 (continued). Comparison of Jonckheere Catalog with the WDS.

Jonck-heere Catalog Number	Designation for the J Number in the WDS Catalog	Notes and Comments	WDS Designations
1075	SEI 1300		SEI 1300 is WDS 20538+3702
1079	SEI 1406		SEI 1406 is WDS 21067+3715
1089	SEI 194		SEI 194 is WDS 05201+3236
1098		**Listed in WDS with no coordinates.**	J 1098 is WDS 06514+1929
1113		**Listed in WDS with no coordinates.**	J 1113 is WDS 20312+3332
1141	ROE 16	ROE 16 AB = J 1141	ROE 16 is WDS 20507+1959
1146	SEI 1531		SEI 1531 is WDS 21402+3703
1147	SEI 1073		SEI 1073 is WDS 20180+3613
1148	SEI 1046		SEI 1046 is WDS 20156+3910
1151	SEI 1355		SEI 1355 is WDS 20596+3558
1152	SEI 1484		SEI 1484 is WDS 21165+3959
1153	SEI 1392		SEI 1392 is WDS 21048+3545
1155	SEI 1521		SEI 1521 is WDS 21305+3701
1157	SEI 602		SEI 602 is WDS 19266+3934
1162	SEI 908		SEI 908 is WDS 20079+3605
1164		No data found	
1166	SEI 998		SEI 998 is WDS 20122+3810
1167	SEI 1038	WDS Note: "J 1230. Probably J 1167. See ADS."	SEI 1038 is WDS 20144+3822
1169		No data found	
1181		**Listed in WDS with no coordinates.**	J 1181 is WDS 19307+0751
1188		**Listed in WDS with no coordinates.**	J 1188 is WDS 18538+1334
1217	J 151		J 151 is WDS 19527+1848
1218		**Listed in WDS with no coordinates.**	J 1218 is WDS 18051+3819
1230	SEI 1038	WDS Note: "J 1230. Probably J 1167. See ADS."	SEI 1038 is WDS 20144+3822
1244		No data found	
1255		**Listed in WDS with no coordinates.**	J 1255 is WDS 05296+0227
1258		**Listed in WDS with no coordinates.**	J 1258 is WDS 07366+0309
1290		**Listed in WDS with no coordinates. Coded "X", Dubious Double**	J 1290 is WDS 19432+0448
1298	HJ 2966		HJ 2966 is WDS 20277+0803
1299	BRT 2186		BRT 2186 is WDS 20284+0746
1311		**Listed in WDS with no coordinates.**	J 1311 is WDS 19359+0727
1314		**Listed in WDS with no coordinates.**	J 1314 is WDS 19461+0728

Table 3 continues on the next page.

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Table 3 (continued). Comparison of Jonckheere Catalog with the WDS.

Jonck-heere Catalog Number	Designation for the J Num-ber in the WDS Catalog	Notes and Comments	WDS Designations
1323	MLL 10	WDS Note: "Probably identical with ADS 4627, J 1323."	MLL 10 is WDS 06030+0945
1329	SEI 1455		SEI 1455 is 21137+3602
1341		**Listed in WDS with no coordinates.**	J 1341 is WDS 20214-0407
1353	ES 1914	WDS Note: "Position corrected by Heintz, who also notes that the pair J 1353 is identical."	ES 1914 is WDS 19057+6502
1355	J 1346		J 1346 is WDS 20560+0837
1359	ES 1483		ES 1483 is WDS 00190+4301
1370	J 1340	WDS Note: "Published in JO XXIV, 21 as J 1370. Jonck-heere calls it 1340 in his 1962 catalogue. Thorel (private comm.) says J 1370 is a novae, however."	J 1340 is WDS 20177+1755
1371	BAL 1192		BAL 1192 is WDS 18032+0047
1373	BAL 585		BAL 585 is 18488-0120
1382		No data found	
1384	HJ 5124		HJ 5124 is WDS 19293-1742
1387	BAL 2019		BAL 2019 is WDS 20122+0255
1391		The note in the WDS Notes File referring HJ 918 AC has been corrected to read "HJ 918 J 1391" with AC dropped since there is no "C" component to HJ 918.	HJ 918 is WDS 20289-0652
1393	DOO 85		DOO 85 is WDS 20296-0650
1405	ARA 502	WDS Notes File: "aka J 1405. Jonckheere gives the lo-cation as "+40s, -1' de la BD-19 6082." If you take a sign error in the RA offset (i.e. 40s west of the BD star rather than east), you land dead on WDS 21216-1825 = ARA 502 with which it matches."	ARA 502 is WDS 21216-1825
1407	RST 4091		RST 4091 is 21399-0842
1412	HJ 3075		HJ 3075 is WDS 21589-1115
1415	RST 4710		RST 4170 is WDS 22432-0326
1418	HJ 3151		HJ 3151 is WDS 22541-1152
1425	BHA 55		BHA 55 is WDS 23392-1831
1426	FOX 276		FOX 276 is WDS 23432-0837
1433	HJ 1961		HJ 1961 is WDS 00234-0121
1435	HJ 1979		HJ 1979 is WDS 00307-1545
1437	CHE 28		CHE 28 is WDS 00353-0942
1440	RST 4158		RST 4158 is WDS 00500-0401
1442	RST 4162		RST 4162 is WDS 01035-0535
1445		No data found	
1452	GAL 323	WDS Notes File: "Object #71 in Gallo's original list. Aka J 1452."	GAL 323 is WDS 02351-1046
1454	BRT 2627		BRT 2627 is WDS 03002-1110
1462	BRT 379		BRT 379 is WDS 06332-0724
1464	RST 4331		RST 4331 is WDS 07028-0716
1468		No data found	

Table 3 continues on the next page.

Mind the Gap – Jonckheere Double Stars Not Listed in the WDS

Table 3 (continued). Comparison of Jonckheere Catalog with the WDS.

Jonck-heere Catalog Number	Designation for the J Num-ber in the WDS Catalog	Notes and Comments	WDS Designations
1469		No data found	
1471	HJ 387		HJ 387 is WDS 06225-0259
1476	BAL 75		BAL 75 is WDS 06458-0225
1477	BAL 77		BAL 77 is WDS 06461-0233
1478	BAL 78		BAL 78 is WDS 06466-0231
1494	BAL 177		BAL 177 is WDS 07328-0230
1499	BAL 484		BAL 484 is WDS 07360-0147
1502	GCB 21	WDS Notes File: "J 1502. BAL 491."	GCB 21 is WDS 07502-0214
1503		No data found	
1511		No data found	
1513	BRT 2708		BRT 2708 is WDS 08174-1125
1517		No data found	
1528	RST 4413		RST 4413 is WDS 08364-0306
1544	DON 1080	WDS Notes File: "J 1544. ARA1764."	DON 1080 is WDS 09188-2250
1546	FOX 161	WDS Notes File: "J 1546. Bal 859."	FOX 161 is WDS 09210-0100
1554	B 779		B 779 is WDS 09389-2016
1574	WHC 9		WHC 9 is WDS 11225-1028
1580	HJ 843		HJ 843 is WDS 11520-0824
1599		No data found	
1600		No data found	
1602	B 2536		B 2536 is WDS 12029-1908
1612	BRT 551		BRT 551 is WDS 14509-0810
1625	HJ 2826	WDS Notes File: "Also known as J 1625 or WHC 16."	HJ 2826 is WDS 18165-1652
1626	B 2862		B 2862 is WDS 18170-1933
1628		No data found	
1635	B 2461	WDS Notes File: "J 1635, J 1750."	B 2461 is WDS 18483-1935
1644	BRT 3058		BRT 3058 is 18042-2846
1652	BRT 2754		BRT 2754 is WDS 18308-1309
1655		WDS Note:" Probably identical to J 2522"	J 2522 is WDS 18422-1022
1659	RST 4602		RST 4602 is WDS 18511-1421
1667	HJ 2856		HJ 2856 is WDS 19135-1632
1669		**Listed in WDS with no coordinates.**	J 1669 is WDS 19147-0245

Table 3 continues on the next page.

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Table 3 (continued). Comparison of Jonckheere Catalog with the WDS.

Jonck-heere Catalog Number	Designation for the J Num-ber in the WDS Catalog	Notes and Comments	WDS Designations
1674	LEO 44	WDS NOTE on LEO 44: "J 1674. J 1757"	LEO 44 is WDS 19244-1400
1679	LV 21 BC		LV 21 is WDS 19377-0958
1683	BAL 605		BAL 605 is WDS 19413-0128
1685	BRT 2766		BRT 2766 is WDS 19455-1133
1689	BAL 1533		BAL 1533 is WDS 19518+0204
1693	J 154		J 154 is WDS 20018-0354
1697	FEN 36	WDS Notes File: "LEO 47. J 1697."	FEN 36 is WDS 0058-1703
1698	BAL 1544		BAL 1544 is WDS 20090+0127
1708	BAL 613		BAL 613 is WDS 20342-0045
1712	BAL 927		BAL 927 is WDS 20523-0030
1722	RST 5161		RST 5161 is WDS 21209-0136
1728	J 291		J 291 is WDS 22332-0046
1730	BRT 2195		BRT 2195 is WDS 23370+0630
1731	J 294		J 294 is WDS 23021+1026
1733	B 415		B 415 is WDS 18591-2609
1734	HJ 1297		HJ 1297 is WDS 17017-2542
1736	ARA 1507		ARA 1507 is WDS 18059-2134
1737	VAT2		VAT 2 is WDS 18125-1852
1739		No data found	
1747	ARA 1544		ARA 1544 is WDS 18354-2118
1749	J 1656		J 1656 is WDS 18457-1624
1750	B 2461	WDS Notes File: "J 1635, J 1750."	B 2461 is WDS 18483-1935
1752	OL 80	WDS Notes File: "DON 934. J 1752".	OL 80 is WDS 18547-1946
1757	LEO 44	WDS Notes File on LEO 44: "J 1757. J 1674"	LEO 44 is WDS 19244-1400
1763	BHA 31		BHA 31 is WDS 19369-2003
1768	POU 4262		POU 4262 is WDS 20119+2351
1769	POU 4263		POU 4263 is WDS 20120+2350
1771	J 1389		J 1771 is WDS 20202-1046
1774	BAL 1560		BAL 1560 is WDS 20281+0140
1777	BAL 2543		BAL 2543 is WDS 20412+0338
1778	HDO 160		HDO 160 is WDS 20456-0853
1780	J 1717		J 1717 is WDS 21037-0258

Table 3 continues on the next page.

Mind the Gap – Jonckheere Double Stars Not Listed in the WDS

Table 3 (continued). Comparison of Jonckheere Catalog with the WDS.

Jonck-heere Catalog Number	Designation for the J Number in the WDS Catalog	Notes and Comments	WDS Designations
1783	HJ 1612		HJ 1612 is WDS 21096-1622
1787	BRT 1356		BRT 1356 is WDS 21236+1030
1792	HJ 3090	WDS Notes File: "J 1792. Not found by Heintz at IDS position."	HJ 3090 is WDS 2077+0913
1796	KU 64 CD		KU 64 is WDS 22227+2849
1799	POU 5863		POU 5863 is WDS 23515+2501
1800	POU 5865	WDS Note File: "J 1800. Same as POU 5866."	PUR 5865 is WDS 23516+2502
1805	POU 107		POU 107 is WDS 01102+2447
1811	BAL 2603		BAL 2603 is WDS 02596+0508
1814	BAL 2119		BAL 2119 is WDS 04171+0409
1822	POU 1237		POU 1237 is WDS 06206+2327
1826		**Listed in WDS with no coordinates. Coded "X", Dubious Double**	J 1826 is WDS 06392+0149
1827	J 1365		J 1365 is WDS 06402+1335
1829	BAL 1957		BAL 1957 is WDS 18121+0207
1844	HJ 885	WDS Notes File also states: "J 2694. BAL1983. J1844".	HJ 885 is WDS 19243+0305
1849	BAL 1998		BAL 1998 is WDS 19334+0227
1855	GCB 45		GCB 45 is WDS 19408+0913
1857	HJ 894		HJ 894 is WDS19398+1945
1866	A 2994 A,BC		A 2994 is WDS 19503+0713
1872	BRT 554		BRT 554 is WDS 20006-0911
1881	HJ 2959		HJ 2959 is WDS 20245+0916
1886	POU 3427		POU 3427 is WDS 18330+2420
1891	BRT 1956		BRT 1956 is WDS 20520+1422
1898	POU 5775		POU 5775 is WDS 23047+2355
1915	HJ 33 AB	WDS Notes File: "HJ 33 also known as J 1915 AC. J 1915 AB also known as AOT 24 AC. J 1915 BC also known as AOT 24BC." Note found on p. 70 of Jonckheere's 1962 catalog: "BC = J 3228."	HJ 33 and AOT 24 also WDS 05569-0700
1916		No data found	
1927	J 1925		J 1925 is WDS 06122+0640
1931	BAL 992		BAL 992 is WDS 06144+0052
1932	BAL 993		BAL 993 is WDS 06146+0051
1936	POU 1187		POU 1187 is WDS 06169+2414
1938	KRU 1		KRU 1 is WDS 06180+2152
1941	L 59		L 59 is WDS 06221+2203
1943	BAL 1313		BAL 1313 is WDS 06239+0111

Table 3 continues on the next page.

Mind the Gap – Jonckheere Double Stars Not Listed in the WDS

Table 3 (continued). Comparison of Jonckheere Catalog with the WDS.

Jonck-heere Catalog Number	Designation for the J Num-ber in the WDS Catalog	Notes and Comments	WDS Designations
1946	BAL 1694		BAL 1694 is WDS 06274+0211
1947	BAL 2169		BAL 2169 is WDS 06274+0354
1948	BAL 1009	WDS Notes Files: "J 1948. J 1996."	BAL 1009 is WDS 06277+0034
1952	BAL 1697		BAL 1697 is WDS 06315+0212
1955	J 2022	WDS Notes File: "RST 5235. BAL 1316. J 1955 has been abandoned."	J 2022 is WDS 06324+0110
1957	J 661		J 661 is WDS 06323+0543
1961	BAL 1318		BAL 1318 is WDS 06352+0100
1968	POU 1891		POU 1891 is WDS 06415+2436
1983	GAU 4894	WDS Notes File: "J 1983. BAL 1061."	GAU 4894 is WDS 06591+0044
1984	GAU 4919	WDS Notes File: "J 1984. BAL 1065."	GAU 4919 is WDS 06598+0037
1992	STF 1063	WDS Notes File: "J 1992. BAL 2753. BAZ 3."	STF 1063 is WDS 07181+0421
1996	BAL 1009	WDS Notes Files: "J 1948. J 1996."	BAL 1009 is WDS 06277+0034
1997	BAL 1098		BAL 1098 is WDS 07282+0035
2000	BAL 2784	WDS Notes File: "J 2486. J 2000."	BAL 2784 is WDS 07449+0349
2001		No data found	
2004	STT 142	WDS Notes File: "The primary is a spectroscopic bina-ry. The pair formerly listed as J 2004 appears to be identical, with distance doubled."	STT 142 is WDS 06299+0707
2007	J 596		J 596 is WDS 06410+0215
2011		No data found	
2015	A 3021	WDS Notes File:" Evidently, the same as J 2015."	A 3021 is WDS 06100-0420
2018	HO 229		HO 229 is WDS 06181+1423
2023		No data found	
2026	J 268		J 268 is WDS 06463+0811
2033	J 274		J 274 is WDS 06553+0816
2047	BAL 1825		BAL 1825 is WDS 07507+0242
2066			
2069		**Listed in WDS with no coordinates. Coded "X", Dubious Double**	J 2069 is WDS 09314-0215
2099	BRT 1513		BRT 1513 is WDS 18060-2238
2105	BAL 555		BAL 555 is WDS 14278-0140
2111	BAL 1481		BAL 1481 is WDS 16599+0121
2114	BAL 891		BAL 891 is WDS 17349-0044
2119	BAL 2462		BAL 2462 is WDS 17590+0259
2120	BAL 2464		BAL 2464 is WDS 17592+0304

Table 3 continues on the next page.

Mind the Gap – Jonckheere Double Stars Not Listed in the WDS

Table 3 (continued). Comparison of Jonckheere Catalog with the WDS.

Jonckheere Catalog Number	Designation for the J Number in the WDS Catalog	Notes and Comments	WDS Designations
2126	BRT 1534		BRT 1534 is WDS 18237-2209
2134	BRT 1945	WDS Note: "J 2134; also J 2137. Jonckheere noted BRT1945 = J 2134; suspected J 2137 at 18356+1007 was probably the same star as well. Identity concluded after search of region, despite fair amt. of discrepancy in some measures.	BRT 1945 is WDS 18355+1005
2139	BRT 2755		BRT 2755 is WDS 18379-1111
2142	HJ 1334	WDS Notes File: "Probably same as J 2142. Jonckheere gives BD as +12@3414; perhaps a misprint for BD+12@3614."	HJ 1334 is WDS 18408+1214
2147	BRT 2757	WDS Notes File: "Possibly BD-12@5164. J 2147."	BRT 2757 is WDS 18469-1222
2162	A 42 CD		A 42 is WDS 19026-0621
2164	BRT 3224		BRT 3224 is WDS 19056+1005
2165	J 1646		J 1646 is WDS 19075-1456
2169	BAL 1511		BAL 1511 is WDS 19133+0153
2190	J 135	WDS Notes File: "J 175. J 2190. OL 193."	J 135 is WDS 20157+1003
2195	ARA 1513		ARA 1513 is WDS 18079-2141
2251	HO 94		HO 94 is WDS 19043-1128
2257	BAL 1515		BAL 1515 is WDS 19168+0141
2281	J 1865		J 1865 is WDS 19485+1958
2299	HO 119		HO 119 is WDS 20111-1252
2301		No data found	
2304	BRT 2771		BRT 2771 is WDS 20131-1111
2323	MLB 534		MLB 534 is WDS 20497+2825
2331		**Listed in WDS with no coordinates.**	J 2331 is WDS 20563+2709
2335	BRT 2487	WDS Notes File: "J 2335. J notes that these are two different pairs."	BRT 2487 is WDS 20589+1741
2338	BAL 620		BAL 620 is WDS 21104-0042
2357	MLB 1050		MLB 1050 is WDS 21456+2709
2362	LEO 51		LEO 51 is WDS 21594-1012
2364		No data found	
2371		No data found	
2372	MLB 582		MLB 582 is WDS 22318+2953
2381	SMA 188		SMA 188 is WDS 23193+4343
2401		No data found	
2402	J 548		J 548 is WDS 20120-0039
2405	ALI 460		ALI 460 is WDS 22435+3645
2407	ES 2540	WDS Notes File: "J 2407, ALI 469."	ES 2540 is WDS 23215+3730
2408	BRT 3372		BRT 3372 is WDS 23355+0850

Table 3 continues on the next page.

Mind the Gap – Jonckheere Double Stars Not Listed in the WDS

Table 3 (continued). Comparison of Jonckheere Catalog with the WDS.

Jonck-heere Catalog Number	Designation for the J Number in the WDS Catalog	Notes and Comments	WDS Designations
2419	OPI 9	WDS Notes File: "J 2419. KRU 2."	OPI 9 is WDS 06179+0919
2424	J 1942	WDS Notes File: "J 2424 is identical"	J 1942 is WDS 06241+2505
2425	J 2815		J 2815 is WDS 07242-0859
2436		No data found	
2437		No data found	
2439	GAU 4375	WDS Notes File: "BAL 725. J 2439."	GAU 4375 is WDS 06485-0018
2442	J 2444		J 2444 is WDS 06530+1441
2455	BAL 3006		BAL 3006 is WDS 07101+0454
2463	RST 4347		RST 4347 is WDS 07183-0317
2466	BRT 1230		BRT 1230 is WDS 07190+1314
2484	BAL 2781		BAL 2781 is WDS 07389+0421
2486	BAL 2784	WDS Notes File: "J 2486. J 2000."	BAL 2784 is WDS 07449+0349
2497	BAL 2361		BAL 2361 is WDS 09214+0248
2501		No data found	
2519	BAL 1503		BAL 1503 is WDS 18394+0111
2529		**Listed in WDS with no coordinates.**	J 2529 is WDS 18470+1126
2544	J 2265	WDS Notes File: "J 2544 is identical."	J 2265 is WDS 19215-0807
2550	BRT 1319		BRT 1319 is WDS 19323+1212
2552	BAL 1206		BAL 1206 is WDS 19345+0037
2557		No data found	
2559	BAL 915		BAL 915 is WDS 19465-0028
2560	BAL 254		BAL 254 is WDS 19514-0215
2562	BRT 1329		BRT 1329 is WDS 19524+1246
2566	BRT 1331		BRT 1331 is WDS 19591+1758
2569	J 1337	WDS Notes File: "J 2569 identical. Corrected position by Heintz."	J 1337 is WDS 20063+0639
2579	BAL 1965		BAL 1965 is WDS 18251+0258
2582	SMA 83		SMA 83 is WDS 19047+0756
2585		No data found	
2586	BRT 2296		BRT 2296 is WDS 00248+1925
2588	BRT 2336		BRT 2336 is WDS 05586+2133
2589		No data found	
2591	BRT 2347		BRT 2347 is WDS 06141+2129

Table 3 continues on the next page.

Mind the Gap – Jonckheere Double Stars Not Listed in the WDS

Table 3 (continued). Comparison of Jonckheere Catalog with the WDS.

Jonck-heere Catalog Number	Designation for the J Number in the WDS Catalog	Notes and Comments	WDS Designations
2595	J 1350	WDS Notes File: "BAL 513. J 2595."	J 1350 is WDS 08503-0156
2596	BRT 1321		BRT 1321 is WDS 19377+1422
2597	BRT 2478		BRT 2478 is WDS 20306+2158
2598	BRT 58		BRT 58 is WDS 21461+2855
2606	A 2434	WDS Notes File: "HIP 26018. See Allen et al. (2000) for information on metallicity,age, galactic orbital parameters, etc. Aka J 2606."	A 2434 is WDS 05331+2002
2608	J 2452		J 2452 is WDS 07062+0425
2609	BAL 64		BAL 64 is WDS 06353-0250
2615		**Listed in WDS with no coordinates. Coded "X", Dubious Double**	J 2615 is WDS 06539+0546
2620	DOO 41	WDS Notes File: "J 2620. One-degree error in WDS designation."	DOO 41 is WDS 06599+0701
2626	BRT 400		BRT 400 is WDS 07138-0502
2628	J 396		J 396 is WDS 07242+1428
2629	BAL 807		BAL 807 is WDS 07251-0050
2630	BAL 1095		BAL 1095 is WDS 07257+0022
2631	J 1064		J 1064 is WDS 07265+0923
2640	FEN 14		FEN 14 is WDS 08267-1910
2646	BRT 1471		BRT 1471 is WDS 08563-1908
2654	FEN 16		FEN 16 is WDS 09549-1750
2655	B 2248	WDS Notes File: "J 2655. BHA 13."	B 2248 is WDS 10320-2021
2656		No data found	
2658	BRT 548		BRT 548 is WDS 11022-0335
2662	FEN 20		FEN 20 is WDS 14279-1806
2684	J 111		J 111 is WDS 18588-0648
2690	J 535		J 535 is WDS 19136-0824
2693	J 1672		J 1672 is WDS 19212-1250
2705	POU 5671		POU 5671 is WDS 22138+2445
2708	BRT 122		BRT 122 is WDS 01060+2456
2709	BRT 2196	WDS Notes File: "ALI 718, J 2709."	BRT 2196 is WDSD 00134+3859
2712		**Listed in WDS with no coordinates.** WDS Note: "Not found by Heintz at IDS position."	J 2712 is WDS 00439+0946
2722	STF 541/ STFA 9	WDS Notes File: "CD : J 2722. This faint pair is between kap 1 and kap 2 Tau."	STF 541/STFA 9 is WDS 04254+2218
2725	BAL 2121		BAL 2121 is WDS 04296+0350
2740	CXT 2		CXT 2 is WDS 06155+1902
2741	BAL 319		BAL 319 is WDS 06220-0202

Table 3 continues on the next page.

Mind the Gap – Jonckheere Double Stars Not Listed in the WDS

Table 3 (continued). Comparison of Jonckheere Catalog with the WDS.

Jonckheere Catalog Number	Designation for the J Number in the WDS Catalog	Notes and Comments	WDS Designations
2743	BAL 1693		BAL 1693 is WDSD 06253+0256
2746	J 2610	WDS Notes File: "BC: Also known as J 2746."	J 2610 is WDS 06375+0134
2752	BAL 1712		BAL 1712 is WDS 06448+0241
2760	BAL 1355		BAL 1355 is WDS 06534+0132
2767	POU 2185		POU 2185 is WDSD 06586+2339
2771	GAL 287	WDS Notes File: "Object #287 in Gallo's original list. GAL 420. J 2771."	GAL 287 is WDSD 07017-1100
2775	RST 4836		RST 4836 is WDS 07041-0038
2779		No data found	
2787		**Listed in WDS with no coordinates. Coded "X", Dubious Double** WDS Notes File: "Not found by Heintz."	J 2787 is WDS 07104+0535
2794		No data found	
2800	J 2459		J 2459 is WDS 07155-1106
2806	BAL 167		BAL 167 is WDS 07176-0221
2808	BAL 168		BAL 168 is WDS 07179-0221
2819	RST 4362		RST 4362 is WDS 07269-0932
2827	J 1490		J 1490 is WDS 07300-0446
2832	BAL 176		BAL 176 is WDS 07326-0250
2856	BAL 492		BAL 492 is WDS 07520-0202
2887	BRT 2713		BRT 2713 is WDS 08464-1413
2898	GCB 24		GCB 24 is WDS 09203-0817
2905	BAL 573		BAL 573 is WDS 17145-0202
2918	J 1748		J 1748 is WDS 18413-0727
2920	J 2919		J 2919 is WDS 18440-0654
2935	POU 3668		POU 3668 is WDS 19029+2429
2955	BRT 2180		BRT 2180 is WDS 19138+0632
2956	BRT 190		BRT 190 is WDS 19137+2905
2957	BRT 2453		BRT 2453 is WDS 19144+2026
2968	KRU 8 CD	WDS Notes: "J 2968. Probable light and velocity variations."	KRU 8 is WDS 19268+2110
2974	GCB 41	WDS Notes File: "Also known as J 2974, TOR 14, PAN 11."	GCB 41 is WDS 19301+1117
2978	POU 3911		POU 3911 is WDS 19336+2414
3001		No data found	
3006	J 2279		J 2279 is WDS 19480+0423
3007	POU 4082 AC		POU 4082 is WDS 19478+2334

Table 3 continues on the next page.

Table 3 (continued). Comparison of Jonckheere Catalog with the WDS.

Jonckheere Catalog Number	Designation for the J Number in the WDS Catalog	Notes and Comments	WDS Designations
3026	BRT 2184		BRT 2184 is WDS 19541+0733
3069	GCB 52	WDS Notes File: "Heintz confirm J 3069 as identical, and corrects both positions."	GCB 52 is WDS 20167+1925
3090	GCB 55		GCB 55 is WDS 20310+2054
3100	BRT 2187		BRT 2187 is WDS 0386+1000
3101		See figures 1 through 6 above	
3123	CXT 1	WDS Notes File: "ROE 53 or J 3123."	CXT 1 is WDS 21046+3345
3176	J 2706	WDS Notes File: "ALI 457. J 3176."	J 2706 is WDS 22370+3716
3177	ES 1997		ES 1997 is WDS 22436+3811
3189	ES 2537		ES 2537 is WDS 23164+3739
3207	BAL 1214		BAL 1214 is WDS 20179+0040
3208	GCB 60		GCB 60 is WDS 20529+0529
3209	BAL 930		BAL 930 is WDS 21073-0021
3212	GCB 29	WDS Notes File: "J 3212. Also known as BRT2222."	GCB 29 is WDS 18017+3714
3214	BRT 2452		BRT 2452 is WDS 19107+2114
3216		No data found	
3219	J 2191		J 2191 is WDS 20185+0626
3222	GCB 58		GCB 58 is WDS 20317+2055
3224	ALD 5		ALD 5 is WDS 21115+3033
3225	BRT 287		BRT 287 is WDS 21149+3037
3228		No data found	
3229	FEN 5		FEN 5 is WDS 06007-1838
3232	BRT 547		BRT 547 is WDS 09424-0750
3233	BRT 435		BRT 435 is WDS 11432-0330
3236	J 3268		J 3268 is WDS 17584+1812
3239	BRT 2792		BRT 2792 is WDS 22143-1109
3247	BRT 2126		BRT 2126 is WDS 06559+0612
3248	GCB 22	WDS Notes File: "BRT 427. J 3248."	GCB 22 is WDS 09151-0825
3259	DOO 30		DOO 30 is WDS 05074+2715
3274	J 2951	WDS Notes File: "J 3274 is probably identical"	J 2951 is WDS 19129+1528
3278	BAL 624		BAL 624 is WDS 21388-0121
3281	RST 5182		RST 5182 is WDS 00351+0209
3284		No data found	

Table 3 concludes on the next page.

Table 3 (conclusion). Comparison of Jonckheere Catalog with the WDS.

Jonck-heere Catalog Number	Designation for the J Number in the WDS Catalog	Notes and Comments	WDS Designations
3285	BAL 845		BAL 845 is WDS 08021-0049
3292	BAL 1151		BAL 1151 is WDS 09292+0024
3295	BAL 1925	WDS Notes File: "J 3295 is identical"	BAL 1925 is WDS 16469+0210
3297	BAL 1936		BAL 1936 is WDS 17238+0219
3298	BAL 2443		BAL 2443 is WDS 17345+0335
3300	BRT 37	WDS Notes File: "19129+2957 J 3300."	BRT 37 is WDS 19128+2957
3302	RST 4696		RST 4696 is WDS 21370-0617
3306		No data found	
3311	BRT 1909		BRT 1909 is WDS 09371-1350
3315	POU 4563		POU 4563 is WDS 20314+2421
3317	ES 214	WDS Notes File: "Also known as J 3317."	ES 214 is WDSD 22155+3450
3318	ES 2389		ES 2389 is WDS 22211+3544
3319	ES 2070		ES 2070 is WDS 22233+3642
3326	BRT 1315		BRT 1315 is WDS 19064+1153
3330	STF 3060 AC		STF 3060 is WDS 00059+1805
3333		No data found	
3334		No data found	
3337		No data found	
3339		No data found	
3341		No data found	
3342	J 2964		J 2964 is WDS 19240+1507
3343		No data found	
3345		No data found	
3347		No data found	
3348		No data found	
3349		No data found	
3350		No data found	
3351		No data found	
3352		No data found	

Ludwig Schupmann Observatory Double Star Measures for the Year 2015

James A. Daley
Ludwig Schupmann Observatory
New Ipswich, NH

Abstract: This report contains measurements in θ and ρ space for ninety-one (91) pairs. Many of these pairs have published orbits of various grades. Most will require long-term observations (hundreds of years in some cases) to be gauged definitive.

A new (replacement) tailpiece stellar coronagraph is finally operational and was employed in a few large Δm observations reported here. The new design features a 60% larger field of view to encompass pairs with separations on the order of 250 seconds of arc with the primary centered in the field. Initial star tests show good images, but for the very corners of the CCD frame. Ray trace results indicate low field distortion (well under 0.1%). This coronagraph is also more mechanically robust than the Ludwig Schupmann Observatory (LSO) package previously reported in this journal (Daley 2007). See photo Figure 1.

Introduction

After a two year (2013-2014) "rest" period, double star observations have resumed at LSO. The telescope used for the measures reported here has remained unchanged and is described in past JDSO articles (see most recently, Daley 2012). Briefly, the instrument is a color-free 9 inch f/11.1 Schupmann Medial used with a Barlow lens to provide an effective focal length (FL) of 286.34 inches. Atmospheric dispersion is easily compensated with the Schupmann design. The (now vintage) CCD detector employed in the measurements was made by Santa Barbara Instrument Group, model ST-7 XE.

Plate scale calibration is performed with a normal incidence coarse objective-grating. A single star of about 2 magnitude is imaged through the grating. To accurately define the wavelength, a 10.0 nm bandwidth interference filter, centered at 589.0 nm, is placed normal to the beam just below the Barlow entrance lens. The grating has bars and spaces of equal widths (about 1cm), thus diffracting only odd orders. Usually the image spacing measurement is made between the plus and minus 5^{th} order. The focal length parameter is adjusted such that the order spacing (in seconds of arc) agrees with that predicted by the grating formula (Jones 1979). After many grating images are averaged, the determined FL value is entered in the system parameters as the working value. The overwhelming advantage of this method of plate scale calibration is that it is independent of the pairs we measure and is also free of tilt anisoplanicity (atmospheric unshared-path angle noise).

The Measures

Data are listed in the conventional way. From left to right: WDS identifier (epoch-2000 RA&Dec), discoverer designation, decimal date of observation, LSO position angle in degrees, LSO separation in seconds of arc, number of nights object was observed, and a notes column with incidental information or a note number for detailed notes appearing at the end of this report.

Almost all measures are the mean of 8-12 sharp images. Position angle corrections are determined by a full-field drift image. The doubles are measured (centroid to centroid) using the camera in its native astrometry mode.

Figure 1. A photo of LSOs new stellar coronagraph. A Lyot stop is incorporated and is easily accessed by removing the screws seen near the barrel's mid-point. The telescope is focused on the field lens/occulting mask seen at the left. The CCD bolt-up flange is to the far right.

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Ludwig Schupmann Observatory Double Star Measures for the Year 2015

Table 1. LSO Measurements of Double Stars

RA+DEC J2000.0	Discoverer Designation	Date	PA (deg)	Sep (")	n	Brief Note
04312+5858	STI 2051 AB	2015.279	59.9	10.23	1	1
05167+4600	FRH 1 AH	2014.101	141.8	722.84	1	2, Capella
05167+4600	ST 3 HL	2015.249	173.9	3.47	1	3
06451-1643	AGC 1 AB	2015.241	80.3	10.67	1	4, Sirius
06451-1643	AGC 1 AB	2016.109	75.5	10.94	1	5
07346+3153	STF 1110 AB	2015.249	54.8	5.03	1	Castor
08122+1739	STF 1196 AB	2015.290	19.6	1.02	1	ζ Cnc
08122+1739	STF 1196 AC	2015.290	62.4	6.33	2	
08122+1739	STF 1196 BC	2015.290	68.6	5.69	2	
08122+1739	STF 1196 AB,C	2015.29	64.8	6.05	2	6
09065+5444	DAL 30	2015.345	12.6	21.39	1	
09104+6708	STF 1306 AB	2015.296	347.8	4.47	1	
09184+3522	STF 1333	2015.304	49.4	1.84	1	
09379+7305	STF 1362	2015.304	124.9	4.93	1	
10178+7104	STF 1415 AB	2015.353	167.8	16.86	1	
10200+1950	STF 1424 AB	2015.334	127.0	4.69	1	γ Leo
11268+0301	STF 1540 AB	2015.378	149.1	28.34	1	7, 83 Leo
11317+1422	STF 1547	2015.391	331.9	15.74	1	
11347+1648	STF 1552 AB	2015.391	209.1	3.37	1	
11390+4109	STT 237	2015.375	244.7	2.06	1	
12001+7039	BU 795 AB	2015.430	328.8	14.56	1	
12001+7039	STT 242 AC	2015.430	158.4	30.74	1	
12001+7039	BU 795 CD	2015.430	111.9	5.92	1	
13064+2109	COU 11	2015.422	314.0	1.77	1	
13375+3618	STF 1768 AB	2015.441	94.6	1.64	1	8, 25 Cvn
13431+0332	STF 1777	2015.449	228.1	2.64	1	
13455+0330	A 1617	2015.449	343.9	1.55	1	
14407+1625	STF 1864 AB	2015.493	111.6	5.51	1	
14450+2704	STF 1877 AB	2015.501	343.3	2.89	1	9, ρ Boo
15038+4739	STF 1909	2015.504	67.9	0.75	1	44 Boo
15183+2650	STF 1932 AB	2015.510	265.5	1.57	1	
15187+1026	STF 1931 AB	2015.504	166.3	13.36	1	
15245+3723	STF 1938 Ba,Bb	2015.501	3.3	2.20	1	
15292+8027	STF 1972 AB	2015.512	77.8	31.75	1	
15382+3615	STF 1964 AC	2015.510	85.5	15.07	1	
15382+3615	STF 1964 CD	2015.510	18.4	1.44	1	
15444+1518	ROE 75	2015.493	327.6	6.20	1	10
15348+1032	STF 1954 AB	2015.510	171.1	3.99	1	δ Ser
15559-0210	STF 1985	2015.510	353.7	6.08	1	
16133+1332	STF 2021 AB	2015.567	357.9	4.13	1	
16147+3352	STF 2032 AB	2015.562	238.3	7.27	1	
16286+5644	STF 2060	2015.586	246.7	3.71	1	
16289+5636	ARG 102	2015.586	53.0	81.85	1	
16289+1825	STF 2052 AB	2015.581	118.0	2.31	1	
16487+3556	STF 2104	2015.600	17.4	5.73	1	
16518+2840	STF 2107 AB	2015.594	104.0	1.41	1	
17053+5428	STF 2130 AB	2015.655	1.8	2.43	1	μ Dra
17248+3044	BU 1250	2015.685	118.4	1.86	2	
17413+6136	STF 2199	2015.660	95.2	17.18	1	
17419+7209	STF 2241 AB	2015.660	15.7	30.19	1	

Table 1 concludes on next page.

Ludwig Schupmann Observatory Double Star Measures for the Year 2015

Table 1 (conclusion). LSO Measurements of Double Stars

RA+DEC J2000.0	Discoverer Designation		Date	PA (deg)	Sep (")	n	Brief Note
18003+5251	STF	2271 AB	2015.671	267.9	3.41	1	
18101+1629	STF	2289	2015.711	219.1	1.16	2	
18239+5848	STF	2323 AB	2015.699	347.3	3.77	1	
18239+5848	STF	2323 AC	2015.699	19.2	89.40	1	
18359+1659	STT	358 AB	2015.728	148.2	1.57	1	
18455+0530	STF	2375 AB	2015.728	120.3	2.48	1	
19069+2210	STF	2455 AB	2015.734	27.8	9.62	1	
19121+4951	STF	2486 AB	2015.731	204.2	7.23	1	
19143+1904	STF	2484	2015.734	240.8	2.07	1	
19252+3708	HJ	1359 AB	2015.740	63.4	2.78	1	
19252+3708	HJ	1359 AC	2015.740	13.49	55.21	1	
19252+0227	STF	2513	2015.781	329.5	1.95	1	
19377+3022	BU	144	2015.737	356.0	6.02	1	
19383+2542	ES	492	2015.792	216.8	5.22	1	11
19449+1047	STF	2570 AB,C	2015.759	276.1	4.33	1	12
19450+4508	STF	2579 AB	2015.764	216.9	2.67	1	13, δ Cyg
20014+1045	STF	2613	2015.789	354.8	3.56	1	
20213+0250	HLD	158	2015.797	46.4	1.02	1	
20329+1142	J	1	2015.803	57.2	2.08	1	
20462+1554	STF	2725	2015.816	12.2	6.24	1	
20467+1607	STF	2727	2015.819	265.5	8.93	1	γ Del
20541+1306	STF	2734	2015.822	227.2	24.37	1	
20595+5013	BU	68	2015.838	148.9	1.88	1	
21031+0132	STF	2744 AB	2015.841	108.3	1.18	1	
21069+3845	STF	2758 AB	2015.836	152.7	31.74	1	61 Cyg
21289+1105	STF	2799 AB	2015.855	259.9	1.82	1	
21441+2845	STF	2822 AB	2015.871	318.8	1.65	1	14, μ Cyg
21441+2845	ES	521 DE	2015.871	286.1	17.47	1	15
22038+6438	STF	2863 AB	2015.877	274.6	8.09	1	16
22234+3228	WOR	11	2015.879	255.3	1.05	1	17
22239+3226	ES	2390	2015.879	323.8	7.65	1	
22266+0424	BU	290 AB	2015.890	226.2	4.08	1	18, 34 Peg
22288-0001	STF	2909	2015.882	164.0	2.14	1	ζ Aqr
22419+2126	STF	2934	2015.912	55.9	1.35	1	
22455+1112	BU	711	2015.901	348.9	2.59	1	
22467+1210	HJ	301 AB	2015.945	94.4	11.06	2	coronagraph
23038+2805	HJ	1842 AB	2015.929	213.6	129.64	1	coronagraph
23038+2805	HJ	1842 AC	2015.929	101.7	241.26	1	coronagraph
23376+4627	STT	600 AB	2015.929	270.8	32.25	1	coronagraph
23376+4627	STT	600 AC	2015.929	76.9	211.43	1	coronagraph
23376+4627	BUP	238 CD	2015.929	160.5	65.97	1	coronagraph
23595+3343	STF	3050 AB	2015.970	340.1	2.36	1	19

Ludwig Schupmann Observatory Double Star Measures for the Year 2015

Notes to Table 1

1. STI2051: This is a fine example of a dM4-DA (white dwarf) binary. It is visually observable with a 7 inch telescope under really dark skies. With my 9 inch medial both the primary and the secondary are visually pretty easy. CCD exposures run about 5 seconds for a high signal to noise ratio.
   I am unaware of a published orbit for Stein 2051[1] despite an orbital arc measuring about 80 degrees. In my opinion, no other binary deserves a preliminary orbit more than this pair. Its astrophysical importance has been recognized for some time. That said, ongoing accurate CCD measures of STI2051 by amateurs will bevaluable indeed.
2. FRH 1AH (Capella): Note that this pair was measured at LSO in 2014. The measure was to judge the practicality of measuring extra-wide doubles with a classic Schmidt camera. The Schmidt was manufactured at LSO and incorporates the observatory's ST-7 CCD. The FOV is over 0.5° on the short axis of the CCD frame. The camera aperture is 6 inches and operates at f/3.3. A 6 inch objective-prism was also made for the Schmidt for obtaining double star spectra: but that's another story! The measure itself indicates a position angle increase of 0.8° since discovery (1895) with very little, if any, change in separation.
3. ST 3HL: Popularly known as Capella H, this close pair orbits Capella with a period probably in the thousands of years (see note 2 above)! HL is not an easy pair to measure with a small telescope. Its faintness along with a magnitude difference of over 3 mags provides the observer a challenge even with a CCD camera. Because the binary is in a critical (outermost) part of its orbit, many measures will be required for at least the next 30 years to better define the ellipse.
   The fixed reference star mentioned in the LSO report (Daley 2009) was also measured and we see a large change, as follows: H Ref 2009.173 (θ = 56.1, ρ = 13.65), H Ref 2015.249 (θ = 46.1, ρ = 15.10). The thought here (given continued observations of H Ref) is that it may help future observers determine the close pair's center of mass.
4. AGC 1AB: Sirius and its white dwarf companion are now separated enough to be observed with a fine 6 inch refractor under the best seeing conditions. Blocking the primary star with a narrow aluminum foil bar, tack glued in the plane of the eyepiece field stop, should reveal "B". The CCD measurement listed here was performed with a shaped-pupil aperture mask and the old tailpiece coronagraph, as described in Daley (2014).
5. Superb seeing and very clear skies prevailed for this measure. As such the images were consistently sharp (one second exposure). The measurement is the mean of the eight best images with a standard deviation of 0.12° in position angle and 0.012" in separation.
6. STF1196AB,C (ζ Cnc): This measurement is between the optical centroid of the well resolved AB pair and the centroid of the more distant "C". If AB were unresolved the result should be much the same, allowing observers with smaller instruments (3-5 inch) to make a fine and important measure.
7. STF1540AB (83 Leo): In addition to the measurement importance itself, wide, slow moving pairs such as this may, for the critical user, provide a test of LSOs measurement precision. Small systematic errors may then be used as a multiplier applied to various pairs reported here. Other such wide pairs are to be found in this report. In general, using these pairs for that purpose presupposes the user has exact data for the wide pair itself and how it was gotten! You see, it is easy to go in circles.
8. STF1768AB (25 Cvn): A difference in magnitude of two makes this close pair difficult. As with all such pairs, seeing must be near perfect. Luck prevailed and 12 nice, sharply resolved, images were captured for this measure.
9. STF1877AB (o Boo): A favorite for testing telescopes, this binary has moved about 22° since discovery. LSO data show no sensible θ change in 15 years with the separation value remaining identical.
10. ROE 75: Very slow moving pair. Since 1993, the double has opened about 0.2" with a θ change of perhaps 1°.
11. ES 492: The WDS listed magnitudes infer a V-band Δm of 0.36. The LSO Δm value for an unfiltered CCD is 0.84 which is roughly an R-band measure. Four high signal-to-noise images were averaged for this Δm result.
12. STF2570AB,C: The primary is AGC 10. The LSO measure is in better agreement with Burnham's Celestial Handbook 1955 listing than the WDS 2001 value[2]. The pair is opening slowly.
13. STF2579AB (δ Cyg): The brightness difference makes this binary a stunning sight in good seeing. In the LSO 9 inch the view is unforgettable, giving the impression of true binarity like no other pair I know.
14. STF2822AB (μ Cyg): This is now a moderately fast moving binary. It is closing with a position angle rate of about 0.9 degrees/yr.
15. ES 521DE: Very few measures, but this pair appears to be physical, as the secondary motion is slightly concave to the primary. Additionally, the pair looks to have common proper motion.
16. STF2863AB: LSO measures show a PA standstill for the past 15 years, however the separation is slightly but smoothly increasing. The speckle pair MCA 69Aa,Ab may cause slight irregular motion, although perhaps not of this magnitude.

[1] *Ed. note: There is an orbit (Strand 1977) associated with this pair, but this is an astrometric orbit (23y) of an unresolved close pair associated with the A component.*

[2] *Ed. note: Agrees well with the UCAC4 (Hartkopf et al. 2013) value of 276.5° & 4.249" for 2001.394.*

Ludwig Schupmann Observatory Double Star Measures for the Year 2015

17. WOR 11: A sparsely measured, but astrophysically important red dwarf pair. I regret not regularly observing this fast moving binary over the last 15 years. The object is faint and difficult, thus providing the amateur a nice challenge.
18. BU 290AB (34 Peg): This is one of the most difficult pairs for the small telescope due to a rather large Δm of about 6.7. Understandably, the binary is under measured. This double has a (preliminary) published orbit (Hale 1994) which can be accessed on the WDS Double Star CD 2006.5. When the LSO data is compared to the orbit diagram, it lies well outside the maximum separation region of the ellipse. The position angle has increased about 2^{o} since 1990. To mitigate diffraction veiling, the binary was imaged using a square pupil mask with an opening of 6 inches on a side. Utilizing a log display helped "bring out" the faint secondary very nicely. A 15-20 second exposure with an R-band filter seemed to work best. Pixel binning (2×2) shortened the required exposure, but naturally degraded the measurement precision, thus this mode was not used in the measurements.
19. STF3050AB: As with BU 290AB above, a significant departure from the published orbit (Starikova 1977) is observed, the data point lying outside the orbit plot in a sharply turning region of the ellipse. Photometric Δm measures in R-band were also made. Six images were measured giving a mean value of 0.18. The effective filter center wavelength is 661.0 nm and the half bandwith is 195.0 nm.

STT Doubles with Large ΔM – Part V: Aquila, Delphinus, Cygnus, Aquarius

Wilfried R.A. Knapp
Vienna, Austria
wilfried.knapp@gmail.com

John Nanson
Star Splitters Double Star Blog
Manzanita, Oregon
jnanson@nehalemtel.net

Abstract: The results of visual double star observing sessions suggested a pattern for STT doubles with large ΔM of being harder to resolve than would be expected based on the WDS catalog data. It was felt this might be a problem with expectations on one hand, and on the other might be an indication of a need for new precise measurements, so we decided to take a closer look at a selected sample of STT doubles and do some research. We found that, as in the other constellations covered so far (Gem, Leo, UMa etc.), at least several of the selected objects in Aql, Del, Cyg and Aqr show parameters quite different from the current WDS data

1. Introduction

As a follow up to our STT reports so far, we continued in the constellations of Aquila, Delphinus, Cygnus, and Aquarius, which contained (with the exception of 3 multiples in Cyg covered in a separate report) 14 objects from our list (see Table 1). All values are based on WDS data as of the begin of 2016.

2. Further Research

Following the procedure for the earlier parts of our report we concluded again that the best approach would be to check historical data on all objects, observe them visually with the target of comparing with the existing data and obtain as many images as possible suitable for photometry.

2.1 Historical Research and Catalog Comparisons

Of the eleven stars in this survey, three of them have notable aspects worth further investigation. Three

Table 1. WDS Values for the Selected Objects at the Beginning of 2016

Name		ID	RA	Dec	Con	Sep	PA	M1	M2	ΔM
STT362	AC	18482+1039	18:48:13.819	+10:38:33.899	Aql	12	104	8.27	14.00	5.73
STT532	AB	19553+0624	19:55:18.791	+06:24:24.301	Aql	13.6	359	3.81	11.90	8.09
STT381	AB	19434+0410	19:43:21.089	+04:10:27.900	Aql	14.7	2	8.00	11.20	3.20
STT368	AC	19160+1610	19:16:01.839	+16:09:39.501	Aql	15.8	108	7.53	11.30	3.77
STT438	AB	21218+4309	21:21:45.801	+43:08:38.102	Cyg	2.3	357	8.27	10.30	2.03
STT427	AB	21037+3104	21:03:39.871	+31:03:44.698	Cyg	4.2	151	7.83	11.90	4.07
STT420	AB	20544+4042	20:54:22.253	+40:42:10.605	Cyg	5.4	0	6.70	10.70	4.00
STT374	AB	19310+5012	19:31:02.423	+50:11:48.701	Cyg	19.4	291	7.60	11.10	3.50
STT412	AB	20457+5040	20:45:43.080	+50:40:25.905	Cyg	25.9	279	7.10	13.10	6.00
STT412	BC	20457+5040	20:45:40.402	+50:40:30.093	Cyg	5.00	186	13.10	13.10	0.00
STT412	AC	20457+5040	20:45:43.080	+50:40:25.905	Cyg	26.20	268	7.27	11.22	3.95
STT409	AB	20403+0326	20:40:17.638	+03:26:28.500	Del	16.8	84	7.06	10.20	3.14
STT460	AB	22057+0147	22:05:39.203	+01:46:56.300	Aqr	13.8	340	8.40	12.80	4.40
STT460	AC	22057+0147	22:05:39.203	+01:46:56.300	Aqr	18.8	30	8.40	12.10	3.70

main research sources were used for this section of the paper, the first of which was W.J. Hussey's *Micrometrical Observations of the Double Stars Discovered at Pulkovo*, published in 1901, which provided preliminary historical information on each of the stars. Hussey's book includes his observations and measures of all the stars originally listed in Otto Wilhelm Struve's 1845 Pulkovo Catalog, as well as data beginning with the date of first measure and continuing through the following years up to 1900. That data, plus inclusion of the background for the Pulkovo Catalog, makes Hussey's book a valuable source of reference. Also consulted was S.W. Burnham's *A General Catalogue of Double Stars Within 121° of the North Pole, Part I* and *Part II*, for information on STT 381 and STT 460. In addition, Bill Hartkopf of the USNO graciously provided the text file for STT 460.

STT 381 (Aql) The intriguing aspect of STT 381 is Hussey's statement that that pair was dropped from the second edition of the Pulkovo catalog because "the companion was regarded as too faint for exact measurement with the 15-inch Pulkowa telescope." According to Hussey's account of STT 381, the pair was first measured by Johann Heinrich Mädler in 1847 at 8° and 15.74", but no magnitudes are shown. However Burnham, in Part I of his 1906 Catalog, lists an 1843 measure by Mädler of 7.5° and 15.79" with magnitudes of 7 and 11 (see Figure 2). Burnham also notes the exclusion of STT 381 from the second Pulkovo catalog, and includes a remark that the secondary wasn't seen by Dembowski in 1865, but notes he (Burnham) found it easy in 1876 with his six inch refractor. Hussey shows magnitudes of 8.0 and 12.0 for the pair in 1899, and Burnham lists them at 7.2 and 11.7 in 1900 (See Figure 2). The WDS shows a more narrow range of 8.0 and 11.20 for the pair. Our photometry resulted in a magnitude of 12.396 for B, but our result for A of 7.775 was hampered by the brightness of A relative to B. We can add that visual observations of B were difficult with a six inch refractor and a 9.25 inch SCT.

STT 409 (Del) This pair was first measured in 1843 by Mädler at 83.6° and 16.33". Hussey notes Otto Struve dropped STT 409 from the second edition of the Pulkovo catalog because the separation exceeded the 16" separation limit set for pairs with secondaries fainter than ninth magnitude. That limit was set by F.G.W. Struve, who began the survey in 1841 and a month later turned it over to his son, Otto (Hussey, 1901, p. 16). There's a tenth magnitude C companion which was added in 1894 by S. Glasenapp.

STT 460 (Aqr) The component of STT 460 which is now designated as C in the WDS was first measured in 1845 by Mädler at 53.9° and 15". The second component, now designated as B in the WDS, was added in 1849 by Otto Struve, with measures of 355.7° and 5.68". However, when the 1850 revision of the Pulkovo Catalog was published, it listed the two components of STT 460 at distances of 1.5" and 7.3". That set off a search by S.W. Burnham (Burnham, 1875) with his six inch refractor which failed to turn up a component at that distance. Hussey also searched for it with the 36 inch Lick refractor on two night in 1898 (Hussey, 1901, p. 182) and was unable to detect a component in the 1.5" range. It appears the 1.5" distance published in the 1850 catalog was very likely a misprint of 15".

The relative positions of the three components have changed rapidly since their discoveries in 1845 and 1849. The AB pair's initial measures (355.7° and 5.68") are virtually unrecognizable when compared to the current WDS measures (2003) of 340° and 13.80"; our measures for the pair are 339.8° and 14.47". The AC pair, first measured at 53.9° and 15", is listed in the WDS at 30° and 18.80" (also from 2003); our measures are 29.5° and 19.33". The WDS text file data for AB and AC displayed in Figure 2.2 highlights the consistent increases in the separations of both pairs, along with steady changes in their position angles.

The proper motion overlay in Figure 3 clearly illustrates the disparate motion of each of the three stars which has resulted in the increasing separation of the components of STT 460. Apart from the B component, the proper motions are not especially high, but as the image shows, each of the three stars is moving away

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9540. OΣ 381 *rej.* Rejected in second edition of the *Poulkowa Catalogue.* Companion not visible to Δ in 1865; easy with 6-inch in 1876. No change shown by the later measures. 37 23

1899.50	5°.9	15".47	3n	Hu	8.0...12.0
1900.51	6.0	15.13	3n	β	7.2...11.7

[Ma (XI, XIII)...Δ (I, p. 229)...Hu (*Pub. L. O.* V)...β5...]

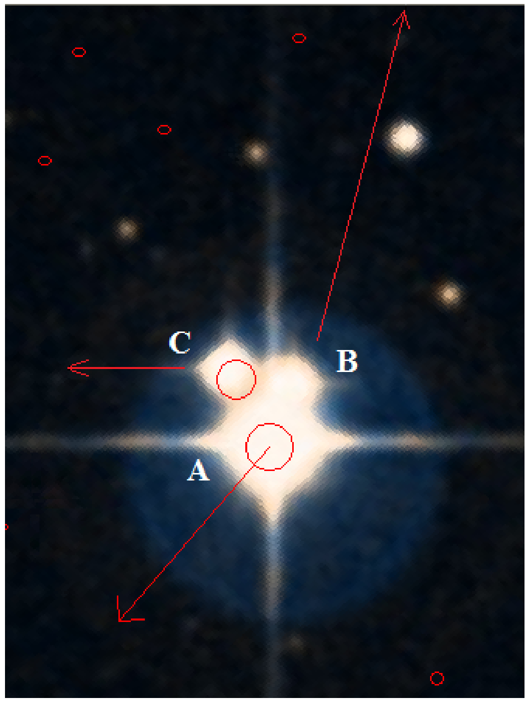
Figure 2. From Burnham's 1906 Catalog of Double Stars, Part II, p. 855.

STT Doubles with Large ΔM – Part V: Aquila, Delphinus, Cygnus, Aquarius

STT 460 AB

	PA	Sep
1849.69	355.7	5.68
1877.80	351.8	6.71
1886.82	351.7	8.05
1898.60	348.0	8.33
1898.67	349.0	8.18
1907.74	348.8	8.93
1907.74	347.5	8.60
1907.79	347.5	8.81
1908.56	347.6	8.83
1908.56	344.8	9.16
1909.65	346.5	8.29
1909.74	348.6	8.00
1909.84	351.9	8.28
1928.15	344.0	10.39
1929.88	343.6	9.98
1961.66	342.4	11.57
2000.60	340.3	13.72
2000.67	340.1	13.56
2003.78	340.1	13.78

WDS Text File Data



	V	UCAC4	pmRA	pmDE
A	VizieR	459-122798	35.5	-40.1
B	VizieR	459-122797	-30.6	142.2
C	VizieR	459-122800	26.9	0.6

STT 460 AC

	PA	Sep
1845.67	53.9	15.00
1849.69	48.3	15.81
1866.53	46.7	15.77
1877.80	46.3	16.04
1886.82	43.6	16.51
1898.60	42.4	16.73
1898.67	44.3	17.02
1907.79	41.1	17.06
1907.79	41.0	16.84
1908.48	40.7	16.69
1908.56	40.7	16.74
1908.56	41.1	17.26
1909.65	41.0	16.76
1909.74	42.2	16.50
1909.84	42.0	16.75
1929.88	38.0	17.25
1961.66	34.6	17.97
2000.60	30.7	18.97
2000.67	31.1	18.86
2003.78	30.4	18.81

WDS Text File Data

Figure 3. Proper Motion of STT 460 Components super-imposed on Aladin image using UCAC4 data.

from the others. (The arrows for B and C, which were added to the image, are not to scale. The arrow for A comes from Simbad's database).

2.2 Visual Observations

Both John Nanson and Wilfried Knapp made visual observations of the stars included in this report. John used a 152mm f/10 refractor, while Wilfried utilized a 140mm refractor and a 235mm SCT, as well as a masking device to evaluate what could be seen at lesser apertures.

STT 362 (Aql): John looked at STT 362 twice and found the B component to be more difficult than expected given the 7.60" separation and the 3.66 magnitudes of difference with the primary. B varied from an elongated smear to a definite point of light for very brief moments, making it impossible to estimate its magnitude. The general impression was B is fainter than the 11.93 shown for it in the WDS. Wilfried also looked at STT 362 twice and was able to split the AB pair on the second observation, but came to no conclusion on magnitude. Neither observer was able to catch sight of the C component. Wilfried was able to see nearby stars in the 13.5 magnitude range, which suggests C is fainter than that magnitude.

STT 368 (Aql): Wilfried observed STT 368 twice and apart from seeing an elongation of the AB pair, was unable to resolve the secondary. He caught a glimpse of C during the second observation at 100x, but was unable to catch sight of it again at higher magnifications, suggesting it may be significantly fainter than the WDS magnitude of 11.3. John resolved the AB pair at 253x and 380x with the six inch refractor during the one observation he made. He was able to see the C component clearly enough at 380x to compare it with three other stars, and found the star with a Vmag of 11.589 was closest in magnitude to C.

STT 381 (Aql): John observed STT 381 once and found the B component was tougher than expected for a pair with a separation of 14.7"and a magnitude difference of 3.2. The one comparison star he found had an incorrect Vmag of 10.298 (UCAC4 471-108123), but the f.mag for that star of 12.412 was more in line with the visual difficulty. Wilfried observed this pair twice and resolved B on the second attempt. He found a comparison star with an f.mag of 11.659 was a

(Continued on page 477)

bit brighter than B, again suggesting B is fainter than the WDS magnitude of 11.2.

STT 409 (Del): Wilfried observed STT 409 once and was able to see B with a limiting aperture of 58mm, suggesting the WDS magnitude of 10.20 is correct. John also made one observation and found B was slightly brighter than a comparison star which was a magnitude fainter than the WDS value. Both observers were able to see C easily.

STT 460 (Aqr): John observed STT 460 several times and found it to be a real visual gem. Both the B and C components were very obvious on first sight, suggesting they're both brighter than the WDS values of 12.80 and 12.10, respectively. Nearby comparison stars suggested a magnitude for B of about 11.3. The C component appeared a bit brighter than B, which suggests a magnitude in the 10.6 range.

STT 532 (Aql): Wilfried observed STT 532 twice and was able to resolve B with averted vision during the first observation at a magnification of 470x. He found a nearby comparison star with an f.mag of 11.778 was similar in brightness to B, suggesting the WDS value of 11.90 is close. John observed STT 532 once and only managed a few fleeting glimpses of B, which were not enough to come to a conclusion on its magnitude.

STT 374 (Cyg): John observed STT 374 once and found the B component was very similar in magnitude to three comparison stars with Vmags ranging from 10.9 to 11.1, agreeing with the WDS value of 11.1. Wilfried looked at STT 374 twice and with the aid of the masking device also confirmed the WDS value.

STT 412 (Cyg): Wilfred viewed STT 412 twice and with the aid of the masking device concluded B is 1.5 magnitudes brighter than the WDS value of 13.1. John observed STT 412 once and found B was obviously brighter than the WDS value. A close comparison with the 11.22 magnitude C companion showed both B and C to be similar in magnitude, with C being slightly brighter than B. Comparison stars indicated the WDS magnitude for C is about right, leading to the conclusion that B is in the 11.5 to 11.8 magnitude range since it appears to about half a magnitude fainter than C.

STT 420 (Cyg): John observed this pair once and found B was very obvious at 190x in the six inch refractor, and also could see it at 152x. Given the 5.4" separation and 4.0 magnitude difference between primary and secondary, the WDS value for B of 10.7 seems to be about right. Wilfried looked at STT 420 twice but was unable to detect B due to poor seeing conditions.

STT 427 (Cyg): Wilfried observed this pair once but was unable to resolve the two stars with a 140mm refractor. John observed it once with a 152mm refractor and was able to see the secondary at 152x and 253x. The difficulty seemed to be about what would be expected given the 4.07 magnitudes of difference and 4.2" separation.

STT 438 (Cyg): John looked at STT 438 twice. Seeing was poor during the first observation, but the secondary was glimpsed briefly a couple of times. During the second attempt, with better seeing, the secondary could be seen as a bump on the edge of the primary at 152x and 253x. A magnitude estimate wasn't possible, but given the three magnitudes of difference and the 2.3" separation, the visual difficulty was about what would be expected. Wilfried also looked at this pair twice. During the first observation, the secondary could be seen at 200x with the aperture reduced to 117mm, which would seem to confirm the WDS magnitude of 10.3 for B. Poor seeing during the second attempt prevented catching sight of the secondary.

2.3 Photometry and Astrometry Results

Several hundred images taken with iTelescope remote telescopes were in a first step plate solved and stacked with AAVSO VPhot. The stacked images were then plate solved with Astrometrica with UCAC4 reference stars with Vmags in the range 10.5 to 14.5mag. The RA/Dec coordinates resulting from plate solving with UCAC4 reference stars in the 10.5 to 14.5mag range were used to calculate Sep and PA using the formula provided by R. Buchheim (2008). Err_Sep is calculated as SQRT(dRA^2+dSep^2) with dRA and dDec as average RA and Dec plate solving errors. Err_PA is the error estimation for PA calculated as arctan (Err_Sep/Sep) in degrees assuming the worst case that Err_Sep points in the right angle to the direction of the separation means perpendicular to the separation vector. Mag is the photometry result based on UCAC4 reference stars with Vmags between 10.5 and 14.5mag. Err_Mag is calculated as

$$Err\_Mag = \sqrt{dV_{mag}^2 + \left[2.5\log_{10}\left(1+\frac{1}{SNR}\right)\right]^2}$$

with $dVmag$ as the average $Vmag$ error over all used reference stars and SNR is the signal to noise ratio for the given star. The results are shown in Table 2 (dRA, dDec, dVmag and SNR not given due to space restrictions).

Summary

Tables 3 and 4 below compare the final results of

(Continued on page 485)

STT Doubles with Large ΔM – Part V: Aquila, Delphinus, Cygnus, Aquarius

Table 2. Photometry and astrometry results for the selected STT objects. Date is the Bessel epoch in 2015 and N is the number of images (usually with 1s exposure time) used for the reported values. iT in the Notes column indicates the telescope used with number of images and exposure time given (Specifications of the used telescopes: See Acknowledgements). The average results over all used images are given in the line below the individual stacks in red and bold. The error estimation over all used images is calculated as root mean square over the individual Err values. The N column in the summary line gives the total number of images used and Date the average Bessel epoch.

STT 362	RA	Dec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	Date	N	Notes
A	18 48 13.818	10 38 34.16	12.065	0.164	105.676	0.779	7.898	0.130	2015.565	5	1
C	18 48 14.606	10 38 30.90					14.357	0.163			
A	18 48 13.821	10 38 34.04	12.156	0.170	104.580	0.800	8.053	0.110	2015.557	5	2
C	18 48 14.619	10 38 30.98					13.983	0.132			
A	18 48 13.822	10 38 34.17	11.836	0.213	105.685	1.029	8.065	0.100	2015.555	5	3
C	18 48 14.595	10 38 30.97					14.292	0.143			
A	18 48 13.830	10 38 34.03	12.037	0.205	105.714	0.977	8.133	0.120	2015.617	5	4
C	18 48 14.616	10 38 30.77					14.128	0.131			
A	18 48 13.823	10 38 34.02	12.119	0.184	105.017	0.869	8.039	0.170	2015.555	5	5
C	18 48 14.617	10 38 30.88					14.267	0.176			
A	18 48 13.818	10 38 34.08	12.135	0.163	105.290	0.769	8.054	0.090	2015.557	5	6
C	18 48 14.612	10 38 30.88					14.291	0.100			
A	18 48 13.862	10 38 34.22	11.955	0.170	104.533	0.813	8.121	0.090	2015.617	5	7
C	18 48 14.647	10 38 31.22					14.214	0.100			
A	**18 48 13.828**	**10 38 34.103**	**12.043**	**0.182**	**105.212**	**0.866**	**8.052**	**0.119**	**2015.575**	**35**	8
C	**18 48 14.616**	**10 38 30.943**					**14.219**	**0.138**			
STT532	RA	Dec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	Date	N	Notes
A	19 55 18.839	06 24 16.67	13.311	0.226	0.577	0.974	5.345	0.141	2015.569	4	9
B	19 55 18.848	06 24 29.98					11.309	0.151			
A	19 55 18.838	06 24 16.35	13.801	0.184	0.619	0.765	4.646	0.150	2015.569	5	10
B	19 55 18.848	06 24 30.15					11.197	0.158			
A	19 55 18.857	06 24 16.53	13.662	0.297	358.937	1.245	4.480	0.121	2015.615	5	11
B	19 55 18.840	06 24 30.19					11.646	0.154			
A	19 55 18.847	06 24 16.66	13.271	0.240	0.772	1.038	5.452	0.121	2015.615	5	12
B	19 55 18.859	06 24 29.93					11.453	0.130			
A	19 55 18.871	06 24 16.84	13.226	0.205	358.256	0.889	5.857	0.113	2015.569	5	13
B	19 55 18.844	06 24 30.06					11.349	0.126			
A	19 55 18.865	06 24 16.77	13.222	0.191	359.096	0.828	6.093	0.134	2015.615	6	14
B	19 55 18.851	06 24 29.99					11.519	0.138			
A	**19 55 18.853**	**06 24 16.637**	**13.414**	**0.227**	**359.713**	**0.971**	**5.312**	**0.131**	**2015.592**	**30**	15
B	**19 55 18.848**	**06 24 30.05**					**11.412**	**0.143**			

Table 2 continues on next page.

Table 2 (continued). Photometry and astrometry results for the selected STT objects. Date is the Bessel epoch in 2015 and N is the number of images (usually with 1s exposure time) used for the reported values. iT in the Notes column indicates the telescope used with number of images and exposure time given (Specifications of the used telescopes: See Acknowledgements). The average results over all used images are given in the line below the individual stacks in red and bold. The error estimation over all used images is calculated as root mean square over the individual Err values. The N column in the summary line gives the total number of images used and Date the average Bessel epoch.

STT381	RA	Dec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	Date	N	Notes
A	19 43 21.085	04 10 27.96	14.519	0.198	2.067	0.781	7.482	0.190	2015.557	5	16
B	19 43 21.120	04 10 42.47					12.106	0.192			
A	19 43 21.077	04 10 27.97	14.528	0.163	1.888	0.642	7.936	0.150	2015.555	5	17
B	19 43 21.109	04 10 42.49					12.550	0.152			
A	19 43 21.092	04 10 27.80	14.556	0.255	1.708	1.003	7.807	0.170	2015.563	5	18
B	19 43 21.121	04 10 42.35					12.443	0.174			
A	19 43 21.088	04 10 27.91	14.701	0.213	2.216	0.829	7.874	0.130	2015.617	5	19
B	19 43 21.126	04 10 42.60					12.483	0.131			
A	**19 43 21.085**	**04 10 27.91**	**14.576**	**0.210**	**1.970**	**0.824**	**7.775**	**0.162**	**2015.573**	**20**	20
B	**19 43 21.119**	**04 10 42.478**					**12.396**	**0.164**			

STT368	RA	Dec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	Date	N	Notes
A	19 16 01.848	16 09 39.85	15.825	0.241	108.609	0.872	7.167	0.110	2015.617	5	21
C	19 16 02.889	16 09 34.80					13.245	0.119			
A	19 16 01.870	16 09 39.51	15.406	0.212	107.646	0.789	7.193	0.090	2015.555	5	22
C	19 16 02.889	16 09 34.84					13.178	0.099			
A	19 16 01.868	16 09 39.73	15.635	0.106	108.689	0.390	7.188	0.120	2015.557	5	23
C	19 16 02.896	16 09 34.72					13.314	0.127			
A	19 16 01.868	16 09 39.52	15.593	0.213	107.889	0.781	7.143	0.090	2015.563	5	24
C	19 16 02.898	16 09 34.73					13.142	0.101			
A	19 16 01.860	16 09 39.83	15.522	0.205	107.936	0.757	7.199	0.080	2015.617	5	25
C	19 16 02.885	16 09 35.05					13.178	0.085			
A	19 16 01.860	16 09 39.63	15.674	0.191	107.948	0.698	7.162	0.070	2015.555	5	26
C	19 16 02.895	16 09 34.80					13.225	0.074			
A	19 16 01.863	16 09 39.76	15.639	0.177	108.568	0.648	7.172	0.070	2015.557	5	27
C	19 16 02.892	16 09 34.78					13.238	0.074			
A	19 16 01.858	16 09 39.37	15.658	0.233	107.238	0.854	7.158	0.070	2015.563	5	28
C	19 16 02.896	16 09 34.73					13.212	0.075			
A	19 16 01.848	16 09 39.85	15.825	0.241	108.609	0.872	7.167	0.070	2015.617	5	29
C	19 16 02.889	16 09 34.80					13.245	0.084			
A	**19 16 01.86**	**16 09 39.672**	**15.641**	**0.206**	**108.128**	**0.755**	**7.172**	**0.087**	**2015.578**	**45**	30
C	**19 16 2.892**	**16 09 34.806**					**13.220**	**0.095**			

Table 2 continues on next page.

STT Doubles with Large ΔM – Part V: Aquila, Delphinus, Cygnus, Aquarius

Table 2 (continued). Photometry and astrometry results for the selected STT objects. Date is the Bessel epoch in 2015 and N is the number of images (usually with 1s exposure time) used for the reported values. iT in the Notes column indicates the telescope used with number of images and exposure time given (Specifications of the used telescopes: See Acknowledgements). The average results over all used images are given in the line below the individual stacks in red and bold. The error estimation over all used images is calculated as root mean square over the individual Err values. The N column in the summary line gives the total number of images used and Date the average Bessel epoch.

STT438	RA	Dec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	Date	N	Notes
A	21 21 45.771	43 08 37.54	2.210	0.220	0.284	5.691	8.089	0.100	2015.639	5	31
B	21 21 45.772	43 08 39.75					9.719	0.101			
A	21 21 45.772	43 08 37.97	2.060	0.198	359.087	5.489	8.150	0.070	2015.621	5	32
B	21 21 45.769	43 08 40.03					9.916	0.072			
A	**21 21 45.772**	**43 08 37.755**	**2.135**	**0.209**	**359.706**	**5.602**	**8.120**	**0.086**	**2015.630**	**10**	33
B	**21 21 45.77**	**43 08 39.89**					**9.818**	**0.087**			
STT427	**RA**	**Dec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**Date**	**N**	**Notes**
A	21 03 39.890	31 03 44.55	3.898	0.264	155.252	3.875	7.682	0.100	2015.639	4	34
B	21 03 40.017	31 03 41.01					10.768	0.102			
A	21 03 39.893	31 03 44.53	4.612	0.172	155.298	2.136	7.455	0.110	2015.700	4	35
B	21 03 40.043	31 03 40.34					10.558	0.111			
A	21 03 39.898	31 03 44.63	4.212	0.198	151.181	2.692	7.641	0.070	2015.615	5	36
B	21 03 40.056	31 03 40.94					11.019	0.072			
A	21 03 39.893	31 03 44.52	3.918	0.184	152.030	2.687	7.674	0.070	2015.621	5	37
B	21 03 40.036	31 03 41.06					10.874	0.071			
A	21 03 39.891	31 03 44.67	4.017	0.170	150.907	2.419	7.663	0.070	2015.632	5	38
B	21 03 40.043	31 03 41.16					10.779	0.072			
A	**21 03 39.893**	**31 03 44.58**	**4.129**	**0.201**	**152.976**	**2.781**	**7.623**	**0.086**	**2015.641**	**23**	39
B	**21 03 40.039**	**31 03 40.902**					**10.800**	**0.087**			
STT420	**RA**	**Dec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**Date**	**N**	**Notes**
A	20 54 22.261	40 42 10.57	5.276	0.234	2.841	2.543	6.622	0.130	2015.637	3	40
B	20 54 22.284	40 42 15.84					10.364	0.133			
A	20 54 22.261	40 42 10.57	5.784	0.283	2.141	2.803	6.586	0.090	2015.639	4	41
B	20 54 22.280	40 42 16.35					10.689	0.095			
A	20 54 22.265	40 42 10.54	5.370	0.186	359.757	1.984	6.411	0.120	2015.700	5	42
B	20 54 22.263	40 42 15.91					10.030	0.121			
A	20 54 22.265	40 42 10.63	5.441	0.177	1.198	1.862	6.616	0.060	2015.615	5	43
B	20 54 22.275	40 42 16.07					10.549	0.062			
A	20 54 22.263	40 42 10.57	5.605	0.191	2.326	1.952	6.612	0.060	2015.620	5	44
B	20 54 22.283	40 42 16.17					10.794	0.090			
A	20 54 22.268	40 42 10.59	5.753	0.191	1.699	1.902	6.603	0.070	2015.632	5	45
B	20 54 22.283	40 42 16.34					10.673	0.077			
A	**20 54 22.264**	**40 42 10.578**	**5.537**	**0.214**	**1.667**	**2.210**	**6.575**	**0.093**	**2015.640**	**27**	46
B	**20 54 22.278**	**40 42 16.113**					**10.517**	**0.099**			

Table 2 continues on next page.

Table 2 (continued). Photometry and astrometry results for the selected STT objects. Date is the Bessel epoch in 2015 and N is the number of images (usually with 1s exposure time) used for the reported values. iT in the Notes column indicates the telescope used with number of images and exposure time given (Specifications of the used telescopes: See Acknowledgements). The average results over all used images are given in the line below the individual stacks in red and bold. The error estimation over all used images is calculated as root mean square over the individual Err values. The N column in the summary line gives the total number of images used and Date the average Bessel epoch.

STT374	RA	Dec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	Date	N	Notes
A	19 31 02.427	50 11 48.92	19.491	0.220	289.949	0.647	7.486	0.050	2015.639	4	47
B	19 31 00.519	50 11 55.57					11.204	0.054			
A	19 31 02.435	50 11 48.67	19.574	0.177	290.204	0.518	7.267	0.110	2015.700	2	48
B	19 31 00.522	50 11 55.43					11.113	0.111			
A	19 31 02.429	50 11 48.89	19.488	0.184	290.014	0.540	7.506	0.050	2015.621	9	49
B	19 31 00.522	50 11 55.56					11.235	0.051			
A	19 31 02.431	50 11 48.90	19.516	0.177	289.985	0.519	7.480	0.060	2015.632	5	50
B	19 31 00.521	50 11 55.57					11.219	0.061			
A	**19 31 02.43**	**50 11 48.845**	**19.517**	**0.190**	**290.038**	**0.559**	**7.435**	**0.072**	**2015.648**	**20**	51
B	**19 31 00.521**	**50 11 55.532**					**11.193**	**0.073**			
STT412	**RA**	**Dec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**Date**	**N**	**Notes**
A	20 45 43.086	50 40 25.93	25.898	0.262	279.243	0.579	7.209	0.130	2015.637	3	52
B	20 45 40.397	50 40 30.09					11.815	0.132			
A	20 45 43.097	50 40 25.94	25.995	0.205	278.986	0.452	7.161	0.130	2015.639	5	53
B	20 45 40.396	50 40 30.00					11.767	0.133			
A	20 45 43.105	50 40 25.88	26.048	0.170	279.056	0.375	6.951	0.140	2015.700	5	54
B	20 45 40.399	50 40 29.98					11.615	0.141			
A	20 45 43.107	50 40 25.96	26.082	0.184	279.133	0.405	7.168	0.110	2015.615	5	55
B	20 45 40.398	50 40 30.10					11.742	0.111			
A	20 45 43.101	50 40 26.10	26.039	0.198	278.926	0.437	7.156	0.100	2015.620	5	56
B	20 45 40.395	50 40 30.14					11.724	0.101			
A	20 45 43.106	50 40 26.01	25.926	0.170	279.099	0.375	7.171	0.100	2015.632	5	57
B	20 45 40.413	50 40 30.11					11.718	0.101			
A	**20 45 43.1**	**50 40 25.97**	**25.998**	**0.201**	**279.074**	**0.442**	**7.136**	**0.119**	**2015.640**	**28**	58
B	**20 45 40.4**	**50 40 30.07**					**11.730**	**0.121**			
STT412	**RA**	**Dec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**Date**	**N**	**Notes**
B	20 45 40.397	50 40 30.09	5.110	0.262	187.160	2.932	11.815	0.132	2015.637	3	59
C	20 45 40.330	50 40 25.02					11.909	0.132			
B	20 45 40.396	50 40 30.00	5.030	0.205	185.096	2.336	11.767	0.133	2015.639	5	60
C	20 45 40.349	50 40 24.99					11.798	0.133			
B	20 45 40.399	50 40 29.98	4.926	0.170	185.870	1.980	11.615	0.141	2015.700	5	61
C	20 45 40.346	50 40 25.08					11.677	0.141			
B	20 45 40.398	50 40 30.10	5.029	0.184	184.988	2.100	11.742	0.111	2015.615	5	62
C	20 45 40.352	50 40 25.09					11.858	0.111			
B	20 45 40.398	50 40 30.10	4.966	0.198	185.823	2.289	11.724	0.101	2015.620	5	63
C	20 45 40.345	50 40 25.16					11.800	0.101			
B	20 45 40.413	50 40 30.11	5.083	0.170	186.550	1.912	11.718	0.101	2015.632	5	64
C	20 45 40.352	50 40 25.06					11.804	0.101			
B	**20 45 40.4**	**50 40 30.063**	**5.023**	**0.201**	**185.919**	**2.288**	**11.730**	**0.121**	**2015.640**	**28**	65
C	**20 45 40.346**	**50 40 25.067**					**11.808**	**0.121**			

Table 2 continues on next page.

STT Doubles with Large ΔM – Part V: Aquila, Delphinus, Cygnus, Aquarius

Table 2 (continued). Photometry and astrometry results for the selected STT objects. Date is the Bessel epoch in 2015 and N is the number of images (usually with 1s exposure time) used for the reported values. iT in the Notes column indicates the telescope used with number of images and exposure time given (Specifications of the used telescopes: See Acknowledgements). The average results over all used images are given in the line below the individual stacks in red and bold. The error estimation over all used images is calculated as root mean square over the individual Err values. The N column in the summary line gives the total number of images used and Date the average Bessel epoch.

STT412	RA	Dec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	Date	N	Notes
A	20 45 43.086	50 40 25.93	26.214	0.262	268.011	0.572	7.209	0.130	2015.637	3	66
C	20 45 40.330	50 40 25.02					11.909	0.132			
A	20 45 43.097	50 40 25.94	26.140	0.205	267.917	0.450	7.161	0.130	2015.639	5	67
C	20 45 40.349	50 40 24.99					11.798	0.133			
A	20 45 43.105	50 40 25.88	26.239	0.170	268.253	0.372	6.951	0.140	2015.700	5	68
C	20 45 40.346	50 40 25.08					11.677	0.141			
A	20 45 43.107	50 40 25.96	26.203	0.184	268.097	0.403	7.168	0.110	2015.615	5	69
C	20 45 40.352	50 40 25.09					11.858	0.111			
A	20 45 43.101	50 40 26.10	26.215	0.198	267.945	0.434	7.156	0.100	2015.620	5	70
C	20 45 40.345	50 40 25.16					11.800	0.101			
A	20 45 43.106	50 40 26.01	26.197	0.170	267.922	0.371	7.171	0.100	2015.632	5	71
C	20 45 40.352	50 40 25.06					11.804	0.101			
A	**20 45 43.100**	**50 40 25.97**	**26.201**	**0.201**	**268.024**	**0.439**	**7.136**	**0.119**	**2015.640**	**28**	72
C	**20 45 40.346**	**50 40 25.067**					**11.808**	**0.121**			
STT409	**RA**	**Dec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**Date**	**N**	**Notes**
A	20 40 17.693	03 26 28.70	16.803	0.255	83.507	0.868	6.930	0.110	2015.637	4	73
B	20 40 18.808	03 26 30.60					10.701	0.111			
A	20 40 17.712	03 26 28.64	16.769	0.304	83.598	1.039	6.907	0.090	2015.639	3	74
B	20 40 18.825	03 26 30.51					10.635	0.092			
A	20 40 17.715	03 26 28.52	16.728	0.184	83.478	0.632	6.698	0.090	2015.700	5	75
B	20 40 18.825	03 26 30.42					10.527	0.091			
A	20 40 17.711	03 26 28.76	16.852	0.213	83.834	0.723	6.847	0.060	2015.615	5	76
B	20 40 18.830	03 26 30.57					10.610	0.061			
A	20 40 17.709	03 26 28.76	16.739	0.213	83.620	0.728	6.961	0.050	2015.620	5	77
B	20 40 18.820	03 26 30.62					10.650	0.050			
A	20 40 17.708	03 26 28.56	16.812	0.177	83.682	0.603	6.885	0.050	2015.632	5	78
B	20 40 18.824	03 26 30.41					10.696	0.051			
A	**20 40 17.708**	**03 26 28.657**	**16.784**	**0.228**	**83.620**	**0.780**	**6.871**	**0.078**	**2015.640**	**27**	79
B	**20 40 18.822**	**03 26 30.522**					**10.637**	**0.079**			
STT460	**RA**	**Dec**	**Sep**	**Err Sep**	**PA**	**Err PA**	**Mag**	**Err Mag**	**Date**	**N**	**Notes**
A	22 05 39.244	01 46 56.04	14.360	0.248	339.719	0.991	8.219	0.120	2015.637	5	80
B	22 05 38.912	01 47 09.51					12.322	0.124			
A	22 05 39.235	01 46 55.80	14.499	0.213	339.606	0.840	8.196	0.080	2015.639	5	81
B	22 05 38.898	01 47 09.39					12.196	0.088			
A	22 05 39.239	01 46 55.56	14.517	0.212	339.758	0.837	8.022	0.110	2015.700	5	82
B	22 05 38.904	01 47 09.18					12.191	0.113			
A	22 05 39.235	01 46 55.83	14.496	0.198	339.980	0.785	8.165	0.100	2015.615	5	83
B	22 05 38.904	01 47 09.45					12.144	0.102			
A	22 05 39.230	01 46 55.82	14.484	0.177	339.647	0.700	8.168	0.080	2015.620	5	84
B	22 05 38.894	01 47 09.40					12.128	0.081			
A	22 05 39.234	01 46 55.77	14.465	0.163	339.620	0.645	8.205	0.050	2015.632	5	85
B	22 05 38.898	01 47 09.33					12.179	0.053			
A	**22 05 39.236**	**01 46 55.803**	**14.470**	**0.204**	**339.722**	**0.807**	**8.163**	**0.093**	**2015.640**	**30**	86
B	**22 5 38.902**	**01 47 09.377**					**12.193**	**0.096**			

Table 2 concludes on next page.

STT Doubles with Large ΔM – Part V: Aquila, Delphinus, Cygnus, Aquarius

Table 2 (conclusion). Photometry and astrometry results for the selected STT objects. Date is the Bessel epoch in 2015 and N is the number of images (usually with 1s exposure time) used for the reported values. iT in the Notes column indicates the telescope used with number of images and exposure time given (Specifications of the used telescopes: See Acknowledgements). The average results over all used images are given in the line below the individual stacks in red and bold. The error estimation over all used images is calculated as root mean square over the individual Err values. The N column in the summary line gives the total number of images used and Date the average Bessel epoch.

STT460	RA	Dec	Sep	Err Sep	PA	Err PA	Mag	Err Mag	Date	N	Notes
A	22 05 39.244	01 46 56.04	19.247	0.248	30.109	0.739	8.219	0.120	2015.637	5	87
C	22 05 39.888	01 47 12.69					11.975	0.123			
A	22 05 39.235	01 46 55.80	19.295	0.213	29.462	0.631	8.196	0.080	2015.639	5	88
C	22 05 39.868	01 47 12.60					11.928	0.087			
A	22 05 39.239	01 46 55.56	19.423	0.212	29.351	0.626	8.022	0.110	2015.700	5	89
C	22 05 39.874	01 47 12.49					11.860	0.112			
A	22 05 39.235	01 46 55.83	19.321	0.198	29.419	0.589	8.165	0.100	2015.615	5	90
C	22 05 39.868	01 47 12.66					11.873	0.102			
A	22 05 39.230	01 46 55.82	19.362	0.177	29.452	0.524	8.168	0.080	2015.620	5	91
C	22 05 39.865	01 47 12.68					11.868	0.081			
A	22 05 39.234	01 46 55.77	19.354	0.163	29.467	0.482	8.205	0.050	2015.632	5	92
C	22 05 39.869	01 47 12.62					11.910	0.052			
A	**22 05 39.236**	**01 46 55.803**	**19.334**	**0.204**	**29.543**	**0.604**	**8.163**	**0.093**	**2015.640**	**30**	93
C	**22 5 39.872**	**01 47 12.623**					**11.902**	**0.096**			

Table 2 Notes:

1. iT21 stack 5x3s. A too bright for reliable photometry. SNR for C<15. Mag B measured with 11.945 with SNR 23.38
2. iT24 stack 5x3s. A too bright for reliable photometry. SNR for C<20. Mag B measured with 11.973 with SNR 44.48
3. iT24 stack 5x3s_3. A too bright for reliable photometry. SNR for C<15. Mag B measured with 11.958 with SNR 42.34
4. iT24 stack 5x3s. A too bright for reliable photometry. SNR for C<20. Mag B measured with 12.138 with SNR 43.31
5. iT24 stack 5x3s_2. A too bright for reliable photometry. Mag B measured with 11.983 with SNR 67,62
6. iT24 stack 5x3s_3. A too bright for reliable photometry. Mag B measured with 11.972 with SNR 76,22
7. iT24 stack 5x6s. A too bright for reliable photometry. Mag B measured with 12.089 with SNR 45.97
8. A too bright for reliable photometry. Average mag for B is 12.008
9. iT24 stack 4x2s. SNR B<20
10. iT24 stack 5x1s
11. iT24 stack 5x1s_2. SNR B<20
12. iT24 stack 5x2s
13. iT24 stack 5x3s. SNR B<20
14. iT24 stack 3x3s_2
15. SNR for B in some images <20 with B sitting directly in a telescope spike. A far too bright for reliable photometryiT24 stack 3x3s_2
16. iT24 stack 5x1s
17. iT24 stack 5x1s_2
18. iT24 stack 5x1s_3
19. iT24 stack 5x3s
20. A too bright for reliable photometry. High dVmag despite good image quality indicates not his good UCAC4 Vmag data quality in this FoV iT24 stack 5x3s
21. iT24 stack 5x1s
22. iT24 stack 5x1s_2
23. iT21 stack 5x1s_3
24. iT24 stack 5x1s_4
25. iT24 stack 5x3
26. iT24 stack 5x3s_2
27. iT24 stack 5x3s_3
28. iT24 stack 5x3s_4
29. iT24 stack 5x3s_5
30. A too bright for reliable photometry. Values for A are probably rather for AB
31. iT18 stack 5x3s. Heavily overlapping star disks, photometry and astrometry unreliable
32. iT24 stack 5x3s. Heavily overlapping star disks, photometry and astrometry unreliable
33. Heavily overlapping star disks, photometry and astrom-

etry unreliable. See Figure 4.
34. iT18 stack 4x3s. Overlapping star disks
35. iT21 stack 4x3s. Overlapping star disks
36. iT24 stack 5x3s. Overlapping star disks
37. iT24 stack 5x3s_2. Overlapping star disks
38. iT24 stack 5x3s_3. Overlapping star disks
39. A too bright for reliable photometry. Overlapping star disks. See Figure 5.
40. iT11 stack 3x3s. Overlapping star disks
41. iT18 stack 4x3s. Overlapping star disks
42. iT21 stack 5x3s. Overlapping star disks
43. iT24 stack 5x3s. Overlapping star disks
44. iT24 stack 5x3s_2. Overlapping star disks. SNR B<20
45. iT24 stack 5x3s_3. Overlapping star disks
46. A too bright for reliable photometry. Overlapping star disks
47. iT18 stack 4x3s
48. iT21 stack 5x3s
49. iT24 stack 5x3s
50. iT24 stack 5x3s
51. A too bright for reliable photometry
52. iT11 stack 3x3s
53. iT18 stack 5x3s
54. iT21 stack 5x3s
55. iT24 stack 5x3s
56. iT24 stack 5x3s_2
57. iT24 stack 5x3s_3
58. A too bright for reliable photometry
59. iT11 stack 3x3s
60. iT18 stack 5x3s
61. iT21 stack 5x3s
62. iT24 stack 5x3s
63. iT24 stack 5x3s_2
64. iT24 stack 5x3s_3
65. Summary line
66. iT11 stack 3x3s
67. iT18 stack 5x3s
68. iT21 stack 5x3s
69. iT24 stack 5x3s
70. iT24 stack 5x3s_2
71. iT24 stack 5x3s_3
72. A too bright for reliable photometry
73. iT11 stack 4x3s
74. iT18 stack 3x3s
75. iT21 stack 5x3s
76. iT24 stack 5x3s
77. iT24 stack 5x3s_2
78. iT24 stack 5x3s_3
79. A too bright for reliable photometry
80. iT11 stack 5x3s
81. iT18 stack 5x3s
82. iT21 stack 5x3s
83. iT24 stack 5x3s
84. iT24 stack 5x3s_2
85. iT24 stack 5x3s_3
86. A too bright for reliable photometry
87. iT11 stack 5x3s
88. iT18 stack 5x3s
89. iT21 stack 5x3s
90. iT24 stack 5x3s
91. iT24 stack 5x3s_2
92. iT24 stack 5x3s_3
93. A too bright for reliable photometry

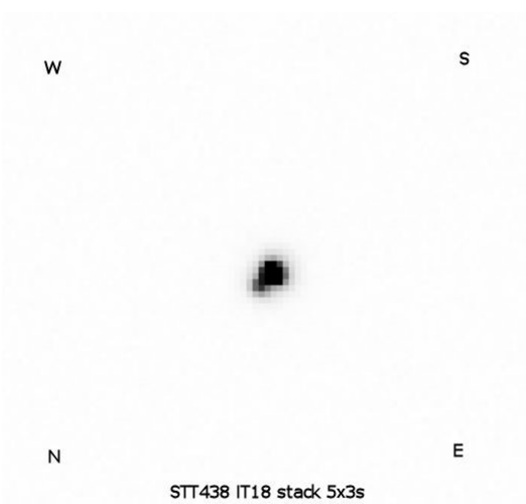


Figure 4. To our surprise, iT18 provided despite rather modest technical specifications, at least a hint of resolution of this close pair with a very bright primary

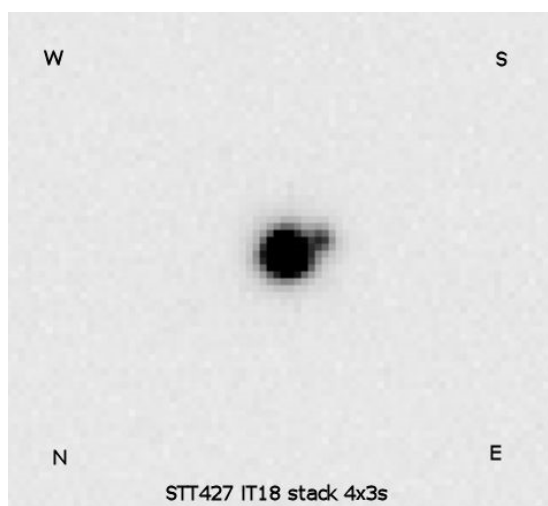


Figure 5. Not as close as STT438, but still difficult to resolve with the equipment currently available to us - again iT18 provided a hint of resolution of this pair with a very bright primary

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our research with the WDS data that was current at the time we began working on our current group of stars.

In Table 3 the results of our photometry have been averaged for each star. Because we're aware that both the NOMAD-1 and the UCAC4 catalogs are frequently consulted when making WDS evaluations of magnitudes changes, the data from those catalogs has also been included for each of the stars.

Red type has been used in Tables 3 and 4 to call attention to significant differences from the WDS data. With regard to Table 3, those magnitudes that differ by two tenths of a magnitude or more from the WDS values have been highlighted. In Table 4, differences in separation in excess of two-tenths of an arc second are highlighted, as are all position angles which differ by more than a degree.

Subsequent to our measures, as a quality check for our astrometry results we turned to the URAT1 catalog for the most recent precise professional measurements available. We used its coordinates to calculate the Sep and PA for all objects in this report for which URAT1 data was available and compared these values with our results, which are shown in Table 5.

Acknowledgements:

The following tools and resources have been used for this research:

- Washington Double Star Catalog as data source for the selected objects
- iTelescope: Images were taken with
  - iT24: 610mm CDK with 3962mm focal length. CCD: FLI-PL09000. Resolution 0.62 arcsec/pixel. V-filter. Located in Auberry, California. Elevation 1405m
  - iT11: 510mm CDK with 2280mm focal length. CCD: FLI ProLine PL11002M. Resolution 0.81 arcsec/pixel. B- and V-Filter. Located in Mayhill, New Mexico. Elevation 2225m
  - iT18: 318mm CDK with 2541mm focal length. CCD: SBIG-STXL-6303E. Resolution 0.73

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Table 3. Photometry and Visual Results Compared to WDS

	WDS Mag	NOMAD-1 VMag	UCAC4 VMa	UCAC4 f. mag	Average of Photometry Measures	Results of Visual Observations
STT 362 C	14.00	-	-	13.627	14.219	Neither observer was able to detect C.
STT 532 B	11.90	-	-	-	11.412	One observation of B, which suggested WDS magnitude is close.
STT 381 B	11.20	-	-	12.062	12.396	Two observations, one suggesting a magnitude near 12.4 and one suggesting a magnitude fainter than 11.7.
STT 368 C	11.30	-	-	13.159	13.220	One observation suggesting C is significantly fainter than the WDS value, one suggesting a magnitude near 11.6.
STT 438 B	10.30	-	9.802	-	9.818	Two observations which suggested B was close the WDS value.
STT 427 B	11.90	-	-	-	10.800	One observation which suggested the WDS value was about right based on difficulty.
STT 420 B	10.70	-	-	-	10.517	One observation which suggested the WDS value was about right based on difficulty.
STT 374 B	11.10	11.520	-	10.976	11.193	Three observations confirming or suggesting the WDS value is close.
STT 412 B	13.10	10.760	-	11.594	11.730	Three observations, all indicating B is about 1.5 magnitudes brighter than WDS value.
STT 412 C	11.22	-	11.220	11.639	11.808	One observation which suggested C is slightly brighter than B.
STT 409 B	10.20	10.104	10.199	9.856	10.637	One observation found B equal to WDS value, one found it about half a magnitude fainter.
STT 460 B	12.80	-	-	12.057	12.193	One observation indicating B is clearly brighter than WDS value, estimate of a magnitude of 11.3 based on comparison star.
STT 460 C	12.10	-	-	11.974	11.902	One observation indicating C is clearly brighter than WDS value and a bit brighter than B – estimate magnitude of 10.6 based on comparison star.

Table 4. Astrometry Results Compared to WDS

	WDS Coordinates	WDS Sep	WDS PA	Astrometry Coordinates	Astrometry Sep	Astrometry PA
STT 362 AC	18:48:13.819 +10:38:33.899	12.0	104	18 48 13.828 +10 38 34.103	12.043	105.212
STT 532 AB	19:55:18.791 +06:24:24.301	13.6	359	19 55 18.853 +06 24 16.637	13.414	359.713
STT 381 AB	19:43:21.089 +04:10:27.900	14.7	2	19 43 21.085 +04 10 27.910	14.576	1.970
STT 368 AC	19:16:01.839 +16:09:39.501	15.8	108	19 16 01.86 +16 09 39.672	15.641	108.128
STT 438 AB	21:21:45.801 +43:08:38.102	2.3	357	21 21 45.772 +43 08 37.755	2.135	359.706
STT 427 AB	21:03:39.871 +31:03:44.698	4.2	151	21 03 39.893 +31 03 44.58	4.129	152.976
STT 420 AB	20:54:22.253 +40:42:10.605	5.4	0	20 54 22.264 +40 42 10.578	5.537	1.667
STT 374 AB	19:31:02.423 +50:11:48.701	19.4	291	19 31 02.430 +50 11 48.845	19.517	290.038
STT 412 AB	20:45:43.080 +50:40:25.905	25.9	279	20 45 43.10 +50 40 25.97	25.998	279.074
STT 412 BC	20:45:40.402 +50:40:30.093	5.0	186	20 45 40.40 +50 40 30.063	5.023	185.919
STT 412 AC	20:45:43.080 +50:40:25.905	26.2	268	20 45 43.100 +50 40 25.97	26.201	268.024
STT 409 AB	20:40:17.638 +03:26:28.500	16.8	84	20 40 17.708 +03 26 28.657	16.784	83.620
STT 460 AB	22:05:39.203 +01:46:56.300	13.8	340	22 05 39.236 +01 46 55.803	14.470	339.722
STT 460 AC	22:05:39.203 +01:46:56.300	18.8	30	22 05 39.236 +01 46 55.803	19.334	29.543

Table 5. Astrometry Results Compared with URAT1 Coordinates

Object	URAT1 Sep	iTelescope Sep	Err Sep	Within Error Range?	URAT1 PA	iTelescope PA	Err PA	Within Error Range?
STT 362 AC	12.070	12.043	0.182	Yes	105.247	105.212	0.866	Yes
STT 381 AB	14.579	14.576	0.210	Yes	2.100	1.970	0.824	Yes
STT 368 AC	15.650	15.641	0.206	Yes	108.214	108.128	0.755	Yes
STT 420 AB	5.697	5.537	0.214	Yes	1.076	1.667	2.210	Yes
STT 374 AB	19.515	19.517	0.190	Yes	290.098	290.038	0.559	Yes
STT 412 AB	26.040	25.998	0.201	Yes	279.048	279.074	0.442	Yes
STT 412 BC	5.011	5.023	0.201	Yes	185.523	185.919	2.288	Yes
STT 412 AC	26.214	26.201	0.201	Yes	268.048	268.024	0.439	Yes
STT 409 AB	16.736	16.784	0.228	Yes	83.640	83.620	0.780	Yes
STT 460 AB	14.407	14.470	0.204	Yes	339.814	339.722	0.807	Yes
STT 460 AC	19.339	19.334	0.204	Yes	29.610	29.543	0.604	Yes

(Continued from page 485)

arcsec/pixel. V-filter. Located in Nerpio, Spain. Elevation 1650m
- iT21: 431mm CDK with 1940mm focal length. CCD: FLI-PL6303E. Resolution 0.96 arcsec/pixel. V-filter. Located in Mayhill, New Mexico. Elevation 2225m

- AAVSO VPhot for initial plate solving
- AAVSO APASS providing Vmags for faint reference stars (indirect via UCAC4)
- UCAC4 catalog (online via the University of Heidelberg website and Vizier and locally from USNO DVD) for counterchecks and for high precision plate solving
- Aladin Sky Atlas v8.0 for counterchecks
- SIMBAD, VizieR for counterchecks
- 2MASS All Sky Catalog for counterchecks
- URAT1 Survey (preliminary) for counterchecks
- AstroPlanner v2.2 for object selection, session planning and for catalog based counterchecks
- MaxIm DL6 v6.08 for plate solving on base of the UCAC4 catalog
- Astrometrica v4.8.2.405 for astrometry and photometry measurements.

Our thanks to Bill Hartkopf for supplying the WDS text file for STT 460.

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Speckle Interferometry of Close Visual Binaries with a 280 mm Reflector and an EM-CCD

J. Sérot
jocelyn.serot@free.fr

Abstract: This paper presents the measurements of 319 visual binary stars obtained between Sep 2015 and Feb 2016 with an 11" reflector telescope and an EM-CCD camera, using speckle interferometry.

1. Introduction

This paper is an addition to the one published in the september special issue of JDSO [1]. It presents the measurements of 319 visual binary stars obtained between Sep 2015 and Feb 2016 with an 280 mm reflector telescope and an EM-CCD camera. The total number of measurements is 323, concerning 319 binaries with magnitudes and separation ranging between 4.4 and 11.3 and 0.4'' and 1,5'' respectively.

2. Equipment

The equipement has already been described in [1]. We therefore only recall its main characteristics. The telescope is a 280 mm Schmidt-Cassegrain reflector (Celestron C11) and the camera a Raptor Kite EM-CCD [2]. The native focal length of the telescope (2.8m, F/D=10) is augmented to 17m using eyepiece projection – which provides more flexible way to adapt the resulting focal length than the telecentric amplifier described in [1] – leading to a plate scale of 0.11''/pixel (pixel size = 10 μm).

An atmospheric dispersion corrector, using a simple pair of Risley prisms [3] is inserted in the optical path to compensate for the effects of atmospheric dispersion when imaging stars not close to the zenith. An IR-cut filter (rejecting all wavelength above 700 nm) is also systematically used.

3. Image acquisition and reduction

Acquisition is carried out with the *Genika Astro* software [4]. For each star 1500 images are acquired. No deconvolution star is used. Exposure time for individual images range from 10 to 40 ms typically and the EM gain of the camera – except for the brightest stars – is set to 90% of the maximum (this value has been determined experimentally : above the SNR is simply too low.

Precise on-sky scale and orientation calibration is performed each observing night using a pair of calibrating stars taken from a list available from the SAF web-site [5].

Selection of the binaries to measure is carried out using the latest, online version of the WDS catalog [6] with the help of the *WdsPick* software introduced in [1]. This software now has the possibility to compute and display the required ADC setting for a given star (knowing the coordinates of this star, the local sideral time and the correction curve of the ADC – which has been determined experimentally.

For practical reasons target stars are systematically observed 1-2 h before the local meridian (observing past the meridian requires a complete mount reversal which is very unpractical). The telescope shed and the ADC range respectively limit the visibility to stars having a declination between 0° and 60°.

Given these ranges, the selection of target stars is based on the magnitude of the components, their last known separation, the total number of measurements and the date of the latest measure as reported in [6].

Image reduction is carried out with the *Reduc* software [7]. Pre-processing (dark substraction, cropping, quality sorting and power spectrum computation) is carried out automatically, in batch mode, the two only steps requiring manual intervention being the final selection of the best images for obtaining lucky images by co-addition (when possible) on the one hand and the measurement of the peak position on the autocorrelogram on the other hand. As described in [1], the former

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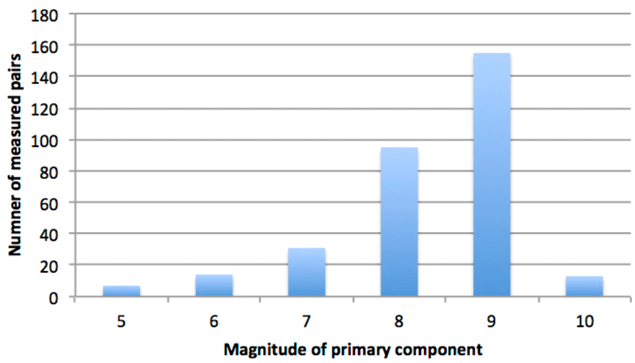


Figure 1. Distribution of measurements according to the magnitude of the primary component

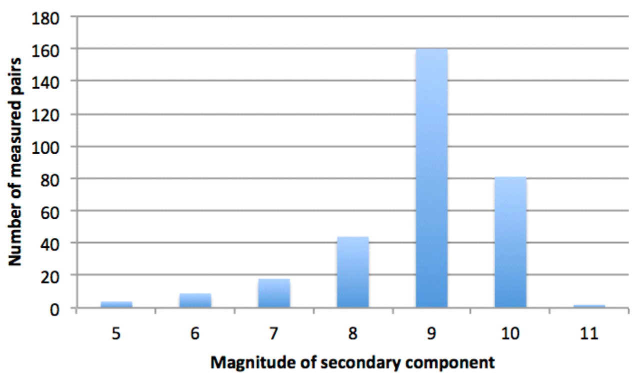


Figure 2. Distribution of measurements according to the magnitude of the secondary component

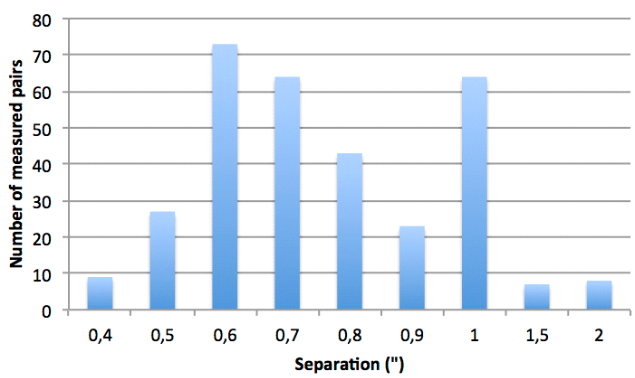


Figure 3. Distribution of measurements according to the separation of components.

is mainly used to overcome the quadrant ambiguity of the other method and, exceptionnaly, when the other method fails because the compagnon is too faint.

4. Results

The reported measurements have been obtained during 21 nights, between 2015-09-09 and 2016-02-05. The total number is 323 mesures, concerning 319 binaries (among these, 66 have a published orbit.

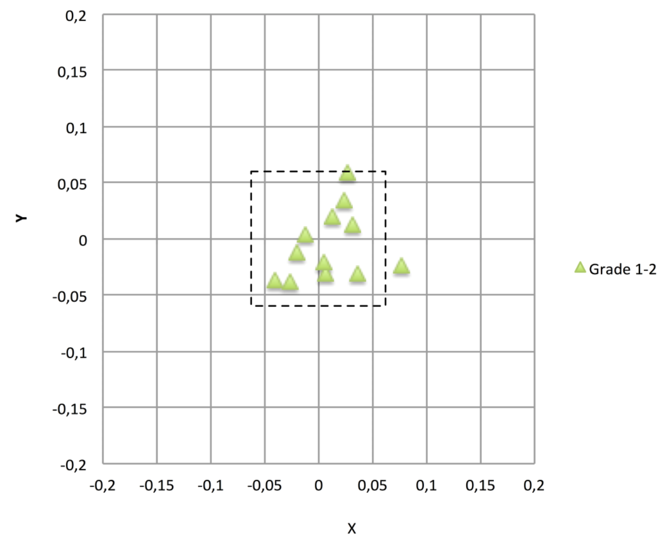


Figure 4. O-C residuals plotted in rectangular coordinates for pairs having an orbit graded 1-2. The dash-lined square represents a pixel in the used instrumental setup.

Figures 1, 2, and 3 show the distribution of all measurements according to the magnitude and separation of components.

These measures are summarized in Table 1, following the habitual JDSO format.

We also report in Table 2. on 18 stars which were either perceived as binaries, but cannot reliably measured because their separation was too close (<0.4'' typically) or were viewed as simple.

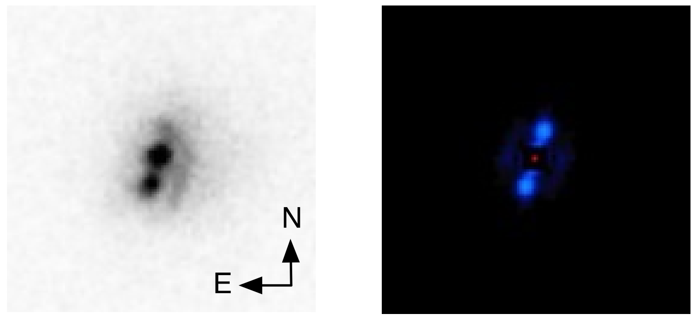
For three pairs our measurement of the position angle exhibits a quadrant inversion compared to the latest one reported in [6]. Our observations are reported in Figure 5 For WDS 21521+2748, the inversion could have been induced by the small difference in magnitude. For WDS 03354+3529 and WDS 02018+4040, the significantly larger difference in magnitude (0.5 and 1.1 respectively) rules out this explanation. Note that for the latters, the number of observations is relatively small (18 and 8 respectively).

For pairs having a known orbit graded 1 or 2, Table 3 gives the O-C residuals, computed from the ephemerids published in the 6th Orbit Catalog [8]. These residuals are plotted in Figure 4 using a polar to rectangular conversion, in order to assess the precision of the measurements.

The details of all measurements (including images) can be obtained online at [9].

(Continued on page 499)

Speckle Interferometry of Close Visual Binaries with a 280 mm Reflector and an EM-CCD

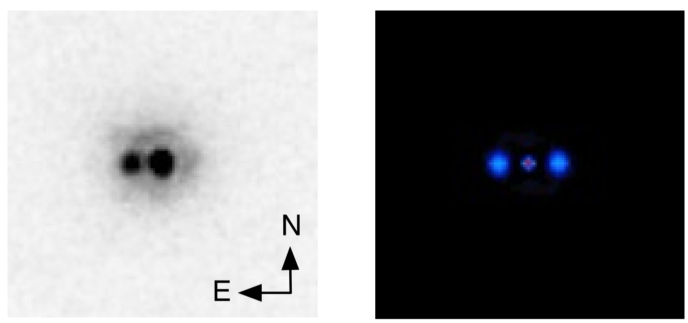


HO 171 (WDS 21521+2748)

m1=9.3, m2=9.5

Observed (2015.74) : PA=162.2, Sep=0.72

Latest measure reported in [8] (2010) : PA=342, Sep=0.7

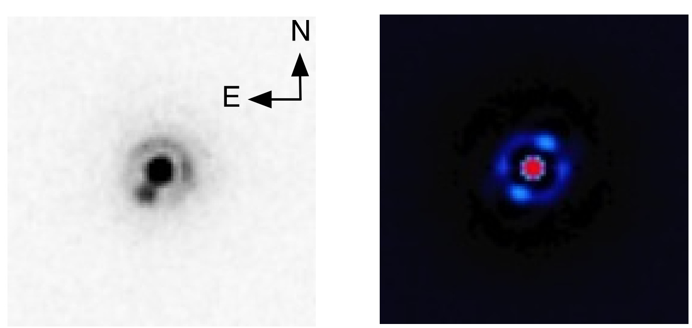


POP 83 (WDS 03354+3529)

m1=9, m2=9.5

Observed (2015.95) : PA=85.6, Sep=0.76

Latest measure reported in [8] (2010) : PA=266, Sep=0.5



A 1923 (WDS 02018+4040)

m1=8.8, m2=9.9

Observed (2015.95) : PA=146.1, Sep=0.71

Latest measure reported in [8] (2008) : PA=325, Sep=0.6

Figure 5. Images of pairs with possible quadrant inversion compared to [6] (left: co-addition of 15 best frames, right: auto-correlogram computed on 1500 frames)

Speckle Interferometry of Close Visual Binaries with a 280 mm Reflector and an EM-CCD

Table 1. Measurements

NAME	RA+DEC	MAGS		PA	SEP	DATE	N	NOTES
HLD 60	00014+3937	9	9.7	167.1	1.21	2015.795	1	1
STF3056AB	00047+3416	7.7	8	144.4	0.71	2015.795	1	
BU 779	00279+2334	8.9	9.4	246.4	0.63	2015.797	1	
A 1504AB	00287+3718	8.8	8.9	41	0.7	2015.852	1	
A 909AB	00297+5855	9.7	10.2	40.8	0.94	2015.852	1	
BU 394AB	00308+4732	8.4	8.7	277.9	0.77	2015.862	2	1
A 911	00334+4739	8.9	9.5	314.1	0.74	2015.852	1	
HU 513	00391+5128	9.4	10.6	210.9	0.95	2015.852	1	
BU 257	00402+4715	8	9.1	253	0.61	2015.797	1	
A 651	00434+4726	9.6	10.2	140.9	0.89	2015.852	1	1
STF 52	00442+4614	7.8	8.9	3.6	1.38	2015.852	1	
BU 865AB	00455+4324	8.6	9.1	192.2	1.23	2015.852	1	
BU 232AB	00504+5038	8.4	8.7	255.6	0.84	2015.797	1	1
HU 1018	00542+5108	9.8	10.2	61.2	0.91	2015.852	1	
STT 20AB	00546+1911	6.1	7.1	175.9	0.59	2015.825	1	1
STF 73AB	00550+2338	6.1	6.5	329.5	1.15	2015.852	1	1
BU 500	00554+3040	8.3	8.7	122.7	0.59	2015.852	1	
BU 867	01014+1155	8.2	9.3	354.1	0.67	2015.86	1	1
STT 21	01030+4723	6.7	8	175.4	1.3	2015.871	1	1
HU 517AB	01037+5026	8.7	9.2	28.2	0.62	2015.871	1	
COU 351	01041+2635	8.7	9.4	242.1	0.8	2015.86	1	
A 929AB	01070+3014	9.9	9.8	134.8	0.67	2015.852	1	
A 2101	01080+1204	9.8	9.9	260	0.68	2015.86	1	
AC 13AB	01089+4512	8	9.5	265.5	0.65	2015.871	1	
A 932	01094+4454	9.5	10.6	333.1	0.88	2015.86	1	
STT 515AB	01095+4715	4.5	5.6	114.2	0.59	2015.797	1	1
BU 303	01097+2348	7.3	7.5	292.5	0.68	2015.852	1	
BU 235Aa,Ab	01106+5101	7.5	7.8	140	0.8	2015.797	1	1
COU1058	01128+3700	9.6	10	252.8	0.82	2015.86	1	
HU 1024	01132+5106	9.6	9.8	207	0.78	2015.86	1	
A 1261	01151+3112	9.7	10	324.4	0.65	2015.871	1	
A 2212	01208+1813	8.5	9.9	213.6	1.27	2015.852	1	
COU 666	01258+2733	9.6	9.7	145.8	0.63	2015.86	1	
AC 14	01283+4247	8.2	8.8	92.7	0.73	2015.852	1	
A 112	01352+5150	9.5	10.1	334.4	1.05	2015.827	1	
BU 508AB	01391+2656	9.8	10	52.8	0.67	2015.86	1	
BU 1167	01403+3844	9.8	10.6	53	1.47	2015.827	1	
COU1661	01406+4447	9.8	10.7	243.4	1.13	2015.871	1	
HU 531AB	01409+4952	9.5	10	352.7	0.47	2015.86	1	
HU 531AB,C	01409+4952	9.8	10	281.5	6.17	2015.844	2	2
BU 509	01437+0934	9.4	9.1	44.4	0.76	2015.827	1	1
STF 149	01445+3957	8.1	9.3	81.3	1.42	2015.852	1	
BU 453AB	01450+5707	10	10.4	110.4	0.78	2015.871	1	1
BU 736AB	01467+3856	9.5	10.9	204.5	0.7	2015.871	1	
BU 1016	01498+3304	9.9	10.1	43.4	0.74	2015.86	1	
BU 1313	01502+2702	8.5	9.4	158.7	0.56	2015.825	1	
BU 260	01532+1526	8.7	8.9	259.1	1.09	2015.825	1	1
STF3113	01535+4437	9.5	9.6	279.8	0.66	2015.852	1	
HU 1033	01557+3620	9.3	9.7	215.1	1.25	2015.852	1	
A 1270	01558+5420	9.4	9.4	220.9	0.7	2015.852	1	
STF 186	01559+0151	6.7	6.8	248.8	0.75	2015.825	1	1
A 1923	02018+4040	8.8	9.9	146.1	0.71	2015.951	1	5

Table 1 continues on next page.

Speckle Interferometry of Close Visual Binaries with a 280 mm Reflector and an EM-CCD

Table 1 (continued). Measurements

NAME	RA+DEC	MAGS		PA	SEP	DATE	N	NOTES
BU 516	02052-0058	8.8	9.2	316.2	0.63	2015.825	1	
HO 497	02128+3722	9.6	9.2	86	0.6	2015.827	1	
STF 228	02140+4729	6.5	7.2	302	0.74	2015.871	1	1
HU 807	02144+3454	9.4	9.9	147.6	0.55	2015.827	1	
COU1368	02150+3742	9.9	10.1	9	0.66	2015.951	1	
STF 236AB	02173+5228	9.4	10	250.7	1.34	2015.995	1	
A 1272	02178+5638	8.6	9.9	23.7	1.17	2015.871	1	
A 207	02182+3920	9.6	10.3	359.7	0.63	2015.871	1	1
HU 808	02196+3315	9.9	10	210.2	0.59	2015.951	1	
STF 248	02211+4246	9.5	9.8	201.6	0.75	2015.995	1	1
HU 536	02231+5233	9.3	9.4	320.3	0.67	2015.951	1	
A 659	02282+4109	9.9	10	274	0.67	2015.871	1	
A 1275	02292+5637	9.8	10	20.6	0.83	2015.827	1	
A 660	02314+4234	8.7	9	312.2	0.61	2015.827	1	
A 1927	02323+3542	8.2	10.3	194	0.79	2015.951	1	
A 1276AB	02333+5619	9.8	9.9	202.5	0.88	2015.827	1	
A 2023	02393+2552	9.3	9.4	226.4	0.59	2015.827	1	
STT 43	02407+2637	7.9	9	338.1	0.61	2015.827	1	1
STT 45	02409+0452	7.3	8.9	262.6	0.84	2015.871	1	
STT 44AB	02422+4242	8.4	8.9	55.6	1.34	2015.995	1	
COU1373	02443+4106	9.8	9.7	261.4	0.7	2015.951	1	
BU 9AB	02471+3533	6.4	8.6	217.7	0.87	2015.951	1	
A 1281AB	02517+4559	8.9	10.7	146.7	0.69	2015.871	1	1
A 973	02535+3134	10	10.5	262.6	0.55	2015.951	1	
A 2413	02572+0153	8.2	8.6	162	0.66	2015.871	1	1
A 1282	02574+5539	9.8	10.1	196	0.72	2015.827	1	
BU 525	02589+2137	7.4	7.4	270.8	0.6	2015.827	1	1
STF 334	02594+0639	7.9	8.2	306.5	1.06	2015.995	1	
STF 346AB	03054+2515	6.2	6.1	258	0.42	2015.951	1	1
BU 1175	03058+4342	7.2	8.8	273.4	0.72	2016.055	1	
BU 1175	03058+4342	7.2	8.8	274.7	0.73	2015.995	1	
A 2416	03066+0046	9.4	9.9	4	0.64	2015.951	1	
A 1533	03078+3652	10.1	10.2	180.9	0.97	2016.055	1	
HU 1055AB	03151+1618	9.4	9.9	119.7	0.62	2015.951	1	1
A 977	03153+5955	9.3	9.9	167.9	0.69	2016.055	1	
WEY 1	03159+3805	10	10.5	262.5	0.92	2015.951	1	
STF 380	03217+0845	9	9.8	5.7	0.94	2015.951	1	1
A 1288	03248+4159	9	9.3	2.9	0.68	2016.055	1	
HU 1058	03250+4013	8.2	8.8	111.1	0.79	2015.814	1	
MLR 686	03251+5601	10.4	10.6	268.5	0.66	2016.055	1	
A 983	03310+2937	9.6	10.2	146.5	0.66	2015.984	1	1
STF 412AB	03344+2428	6.6	6.8	352.3	0.76	2015.951	1	1
POP 83	03354+3529	9	9.5	85.6	0.76	2015.967	2	5
A 1933	03355+0625	8.9	9.9	136.1	1.1	2015.984	1	
A 2419	03372+0121	8.7	8.9	98.8	0.84	2015.984	1	
A 1536	03375+4321	9.4	10.3	227	1.28	2015.984	1	
HLD 9AB	03377+4807	9.5	9.8	54.3	1.29	2016.063	1	
BU 880AB	03446+3210	9.2	9.5	18.2	0.64	2016.063	1	6
STF 439AB,C	03446+3210	8.8	10.3	39.2	23.39	2016.063	1	2.7
HO 504	03446+3551	9	9.1	193.7	1.19	2016.063	1	
BU 537	03471+2449	8.7	10.7	218.6	0.62	2016.063	1	
HU 209AB	03492+5023	9.2	10.3	105.5	1.39	2015.984	1	
STF 461	03554+5630	8.5	10.3	116.7	0.89	2016.063	1	
A 1708	03594+4321	9.7	10.1	335.7	0.87	2015.814	1	
STT 69	03597+3849	6.6	9.1	325.6	1.31	2015.814	1	
A 996	04027+4700	8.5	10.4	273.9	1.49	2015.918	1	
STF 483	04041+3931	7.3	9.3	53.4	1.59	2015.918	1	1
A 1710	04064+4325	8.1	8.2	311.9	0.67	2016.063	1	1

Table 1 continues on next page.

Speckle Interferometry of Close Visual Binaries with a 280 mm Reflector and an EM-CCD

Table 1 (cointinued). Measurements

NAME	RA+DEC	MAGS		PA	SEP	DATE	N	NOTES
STT 531AB	04076+3804	7.3	9.6	354	2.8	2015.918	1	1.2
STT 531AB	04076+3804	7.3	9.6	353.3	2.85	2015.984	1	1
BU 545CD	04076+3804	8.8	10.7	314.5	1.21	2015.984	1	3
BU 546	04115+4152	9.3	9.3	229.2	0.93	2016.063	1	
A 1298	04118+2559	8.9	10.6	171	1.06	2015.984	1	
STT 77AB	04159+3142	8	8.2	297.8	0.54	2016.063	1	1
STF 520	04182+2248	8.2	8.4	80.9	0.7	2016.063	1	1
A 1836	04216+0523	9.7	10.1	197	1.35	2015.984	1	
STT 82AB	04227+1503	7.3	8.6	328.4	1.24	2015.918	1	1
HO 15	04245+3007	10	10	146.9	0.79	2015.918	1	
HU 608	04262+3544	10	9.9	51.5	0.61	2015.918	1	1
HU 1081	04315+1321	9	9.8	271.1	0.75	2015.984	1	
A 1839	04324+3849	9.4	9.8	274.2	0.78	2016.096	1	
A 1839	04324+3849	9.4	9.8	265.9	0.86	2015.932	1	
A 2034	04347+1130	9.1	9.5	239.1	0.637	2016.06	2	
A 1716	04353+4141	9.7	9.8	89.6	0.68	2015.918	1	
STT 86	04366+1946	8.6	7.7	354.9	0.62	2015.984	1	1
A 1010	04378+4442	8.7	9.4	344.8	0.52	2015.918	1	
A 1011	04380+4427	9.4	10.1	26.9	0.83	2015.918	1	
STF 565AB	04381+4207	7.6	9.1	166.4	1.32	2016.096	1	
STF 566AB,C	04400+5328	5.5	7.4	169.8	0.77	2016.055	1	1
HU 552	04465+5507	9.5	10.2	242	1.31	2016.063	1	
A 1544AB,C	04475+4324	8.7	10	19.8	1.35	2016.055	1	
COU1714	04557+4124	9.9	10	132.7	0.68	2015.918	1	
COU1716	04574+4204	9.9	9.8	151.8	0.72	2015.918	1	
D 6	05010+1430	9.1	9.4	99.4	1.06	2016.096	1	
COU2461	05013+4717	9.9	11	7.9	1.46	2016.096	1	
A 2632	05041+0257	9.5	9.7	299.89	0.865	2016.1	1	
A 1024	05044+2938	8.8	9.9	334.4	0.76	2016.096	1	
STT 95	05055+1948	7	7.5	293.2	0.91	2016.096	1	1
STT 98	05079+0830	5.7	6.6	286.4	0.9	2015.932	1	1
COU1868	05115+3938	9.8	9.9	183.2	0.64	2015.932	1	
A 2638	05159+0345	9.2	9.4	279.4	0.94	2016.096	1	
A 2639	05181+0342	8.5	9.6	273.1	0.86	2016.096	1	
A 1560	05238+5334	9.5	9.8	217.1	1.08	2016.055	1	
BU 1317	05243+3939	9.3	9.3	17	0.71	2015.932	1	
A 1719CD	05244+4237	8.8	9.7	89.5	0.85	2016.055	1	
HU 1104	05250+3715	9.2	10.1	221.2	0.93	2015.932	1	
HU 1226	05251+1522	9.7	9.8	54.8	0.67	2016.096	1	
HO 226AB	05270+2737	8.7	8.6	90.9	0.7	2015.932	1	
A 2106	05340+2225	9.7	10.8	301.5	1.49	2015.918	1	
A 1038	05403+4421	9.9	9.9	188.7	0.69	2015.932	1	
A 2110AB	05421+2135	9.5	9.7	133.2	0.51	2015.918	1	
A 117AB	05436+1300	8.8	9.2	249.3	0.82	2015.984	1	
A 1040	05447+3118	8.9	9.4	84.7	0.85	2015.984	1	
HU 1110	05449+3735	8.8	10.7	233.7	0.68	2015.984	1	
A 1567	05449+5543	9.2	10	106.6	1.28	2016.055	1	
HU 38	05450+2255	9	9.4	134.1	0.5	2015.918	1	
A 1041	05459+2607	9.9	10	224.2	0.74	2015.918	1	
HU 1232	05459+3558	10.1	10.1	81.1	0.62	2016.055	1	
STF 787AB	05460+2119	8.2	8.8	56.4	0.68	2015.918	1	
HU 1233	05494+3611	9.4	9.6	33.7	0.69	2015.984	1	
HU 1233	05494+3611	9.4	9.6	32.1	0.74	2015.932	1	
A 1313	05512+5623	9.4	9.8	135.9	0.83	2016.055	1	
A 2714	05538+0633	9.1	9.2	322.1	0.75	2015.984	1	
HU 1234	05572+3623	9.3	9.3	138.6	0.69	2015.984	1	
STT 124	05589+1248	6.1	7.3	295.2	0.72	2016.055	1	1

Table 1 continues on next page.

Speckle Interferometry of Close Visual Binaries with a 280 mm Reflector and an EM-CCD

Table 1 (cointinued). Measurements

NAME	RA+DEC	MAGS		PA	SEP	DATE	N	NOTES
A 1727	06000+4643	10	10	249.2	0.63	2016.068	1	
A 2810	06191+1037	9.7	9.4	75.4	0.52	2015.948	1	
J 345	06203+1159	9.4	10.6	333.1	1.21	2015.948	1	
A 1954	06211+3619	8.5	9.5	105.5	0.74	2015.948	1	8
HO 25AB	06224+2514	10.1	10.3	249.6	0.84	2016.068	1	
A 2720AB	06234+1432	9.3	10.8	52.9	1.08	2015.948	1	
COU1543	06243+3207	10.2	10.5	102.9	1.45	2016.068	1	
A 2722	06249+1424	9.2	10.4	329.4	0.93	2015.948	1	
A 2356	06250+4233	8.8	9	262.9	0.81	2016.068	1	
A 2723	06258+0746	9.7	10.5	28.3	0.81	2015.918	1	
A 2724	06259+0431	8.3	9.1	192.9	0.77	2015.918	1	
COU 41	06277+1822	9.6	9.6	40	1.13	2016.068	1	
HU 562	06289+4944	9	10.7	4.4	1.17	2016.068	1	
A 2726	06293+1233	9	9.2	122.8	0.65	2015.918	1	
BU 1021	06317+2823	8.6	9.3	74.8	0.71	2015.918	1	
WOR 6	06323+5225	10.4	10.5	154.7	0.8	2016.055	1	1
BU 194	06363+3800	8.5	8.9	276.5	1.54	2016.055	1	
STT 149	06364+2717	7.1	8.9	277.7	0.74	2015.918	1	1
A 1051	06368+4415	10.4	10.2	216.5	0.7	2016.055	1	
A 2452	06381+1953	9.2	9.6	88.9	0.92	2015.948	1	
A 2451	06383+4201	9.6	9.7	144.8	0.68	2015.918	1	
STH 1	06392+0939	8.4	8.5	281.1	0.76	2015.948	1	
STT 152	06396+2816	6.2	7.8	33.5	0.83	2016.068	1	
STF 936	06397+5806	7.2	9	284.3	1.1	2016.068	1	
A 1053	06404+2505	9.4	9.8	333	1.02	2015.948	1	
STF 945	06404+4058	7.2	8.3	335.9	0.46	2015.918	1	1
COU 86	06406+2314	10.3	10.5	219.8	1.08	2016.055	1	
HU 563Ca,Cb	06408+4815	9.9	10.5	349.7	0.69	2015.918	1	
A 2456AB	06440+4053	10.4	10.4	320.6	0.56	2016.055	1	
A 511	06443+2822	9.6	10.4	157	1.56	2016.068	1	
A 2522	06451+3555	10	10.3	245.46	0.697	2016.07	1	
HO 239AB	06500+1442	8.9	9.5	148.2	0.47	2015.918	1	
A 1736AB	06528+4712	8.1	10.6	216	0.88	2015.948	1	
HEI 121	06535+1606	9.9	10	267.5	1.22	2015.918	1	
STT 159AB	06573+5825	4.4	5.5	233.9	0.71	2016.055	1	1
BU 899AB	06592+1843	9	9.8	264.1	0.79	2015.918	1	
STF1000AB,C	06594+2514	8	9	67	22.06	2016.068	1	2.4
HEI 717	07015+1009	10	10	166.9	0.96	2016.068	1	
A 2464	07046+1550	9.1	9.7	40.1	0.73	2016.063	1	
A 1741	07052-0052	8.3	8.8	28.2	1.01	2015.948	1	
HEI 848	07082+0601	9.9	10.5	261.6	0.93	2015.948	1	
STF1037AB	07128+2713	7.2	7.2	304.5	0.88	2016.068	1	1
STF1037AB	07128+2713	7.2	7.2	304.8	0.93	2015.948	1	1
A 2860	07197+1343	9.7	10	94.9	0.61	2016.063	1	
A 2045	07268+4611	9.1	10.3	9.7	0.89	2016.096	1	
A 2046	07294+4717	8.2	9.8	247.8	1.44	2015.948	1	
STF1093	07303+4959	8.7	8.9	204.9	0.87	2015.948	1	1
POP 105	07325+3543	9.8	10	48.6	0.79	2015.948	1	
COU2487	07362+4417	10	11	211.4	1.05	2015.948	1	
A 2875AB	07387+1302	9.6	9.8	286.6	0.84	2016.063	1	
A 2531	07390+0058	8.1	10.2	5	1.23	2015.948	1	
STF1126AB	07401+0514	6.5	6.9	174.5	0.78	2015.948	1	
A 2876AB	07417+1803	8.9	10.1	195.6	0.93	2016.063	1	
STT 177	07417+3726	7.9	9.2	152.6	0.56	2016.063	1	1
A 2877	07420+1145	9.6	9.8	62.5	0.76	2015.948	1	
A 2743	07506+0650	9.7	9.9	197.5	0.66	2015.948	1	
STF1145	07513+3849	8.7	10.3	41.9	1.25	2016.096	1	
COU2075	07556+3630	8.5	9	142.9	0.81	2016.096	1	

Table 1 continues on next page.

Speckle Interferometry of Close Visual Binaries with a 280 mm Reflector and an EM-CCD

Table 1 (continued). Measurements

NAME	RA+DEC	MAGS		PA	SEP	DATE	N	NOTES
A 2469	08038+4043	9.7	10.7	43.1	1.37	2016.063	1	
HU 850	08094+3734	9.4	9.2	348.8	0.57	2016.079	2	
STF1196AB	08122+1739	5.3	6.2	18.3	1.12	2016.063	1	1
STF1196AC	08122+1739	5.3	5.8	61	6.3	2016.063	1	
STF1205	08194+5627	9.6	10	166.4	1.73	2016.096	1	
A 2895AB	08330+0958	9.8	9.9	55.3	0.85	2016.096	1	
A 1584	08531+5457	8.9	7.7	90.2	0.71	2016.096	1	1
HU 722	09067+5038	9.1	9.1	237.1	0.56	2016.096	1	
A 1762	09277+4456	9.9	9.8	102.6	0.81	2016.096	1	
STF1356	09285+0903	5.6	7.2	109.2	0.83	2016.096	1	1
A 2761	09435+0612	8.9	9.2	253.9	1	2016.096	1	
A 178	21059+2118	8.8	10.3	63.8	0.91	2015.74	1	
COU1333	21093+3131	9.3	9.4	260.5	0.65	2015.74	1	
COU1967	21097+3856	9.7	10	185.7	0.77	2015.74	1	
COU2652	21127+4900	10.1	10.3	336.8	0.75	2015.74	1	
BU 162AB	21171+3546	8.6	8.8	253.2	1.2	2015.852	1	
HO 153	21177+3345	8.5	9.5	127.5	0.96	2015.852	1	
BU 289AB	21183+3456	9.1	9.6	127.4	0.8	2015.852	1	
STT 435	21214+0253	8.3	8.2	236.7	0.75	2015.852	1	
A 1442	21264+3909	9.4	10.9	273.9	1.29	2015.74	1	
A 619	21268+4228	9.3	9.8	61.3	0.74	2015.74	1	
STF2799AB	21289+1105	7.3	7.4	259.4	1.92	2015.688	1	1
HU 963	21297+1356	8.9	10.4	228.8	0.89	2015.688	1	
COU1973	21302+4143	10.3	10.8	194.3	0.83	2015.74	1	
A 769	21308+4752	9.1	9.2	295.8	0.72	2015.688	1	
A 2291	21349+0308	9.9	10.1	87.8	0.98	2015.688	1	
COU1481	21356+3446	9.4	9.7	177.7	0.5	2015.797	1	
A 403	21421+4414	10	9.9	73.5	0.57	2015.74	1	
BU 688AB	21426+4103	8.1	8.6	193.7	0.55	2015.852	1	
HU 693	21439+5034	9.2	9.9	235.5	1.08	2015.74	1	
HO 168AB	21454+4356	9.4	9.5	39.7	0.83	2015.74	1	
HU 281	21489+0523	9.9	10.5	146.4	1.44	2015.688	1	
HO 171	21521+2748	9.3	9.5	162.3	0.72	2015.74	1	5
BU 75AB	21555+1053	8.4	8.5	26.1	1.04	2015.688	1	1
STT 452	21557+0715	9	9.6	176.4	0.7	2015.688	1	
STT 453AB	21565+0715	8.8	9.5	267.9	0.75	2015.688	1	
BU 1214AB	21566+3421	9.5	10.9	207.3	1.36	2015.74	1	
A 1897	21568+5558	9.6	9.9	73.6	0.98	2015.852	1	
A 1898	21583+5616	9.3	10.4	224.9	1.26	2015.852	1	
A 304AB	21585+2725	9.5	9.3	130.7	0.62	2015.688	1	
HO 175AB	22009+4338	7.8	9.5	318.7	0.73	2015.74	1	
A 780AB	22013+4515	9.4	9.9	148.7	1.49	2015.74	1	
HO 610AB	22020+2651	10	10.2	240.1	0.72	2015.74	1	
A 307	22025+2612	9.7	9.7	136.8	0.52	2015.856	2	
COU1826	22053+4308	9.7	10.6	176.1	0.89	2015.86	1	
A 1453	22054+3858	9.9	9.9	331.6	0.65	2015.852	1	
A 183	22059+4522	9.6	10.1	246.4	0.76	2015.852	1	
COU2550	22077+5020	9.9	10.2	116.3	0.7	2015.86	1	
BU 375	22091+5047	8.9	10.4	301.1	0.95	2015.86	1	
EGG 4	22110+2429	9.4	9.3	152.3	0.61	2015.797	1	
A 409	22116+4056	9.9	10	5.1	0.47	2015.86	1	
HO 179AB	22126+3013	8.6	9.4	280.8	0.84	2015.797	1	
BU 991	22136+5234	9.2	9	139.6	0.68	2015.86	1	
A 410	22149+4142	9.8	9.9	352.2	0.73	2015.74	1	
HO 180AB	22158+4354	7.9	8.7	238.9	0.78	2015.688	1	
HU 595	22173+5049	8.8	9.5	219	0.67	2015.86	1	
A 185	22201+4625	10.2	10.3	137.9	0.81	2015.74	1	

Table 1 concludes on next page.

Speckle Interferometry of Close Visual Binaries with a 280 mm Reflector and an EM-CCD

Table 1 (conclusion). Measurements

NAME	RA+DEC	MAGS		PA	SEP	DATE	N	NOTES
BU 1216	22202+2931	8.6	9.2	273	0.87	2015.688	1	1
BU 1216	22202+2931	8.6	9.2	275	0.89	2015.797	1	1
HU 493	22247+1914	9.8	10.1	170.4	0.81	2015.688	1	
A 2498	22255+4227	10	10.1	350.2	0.65	2015.74	1	
COU 539	22269+2653	9.3	10.3	195.5	0.67	2015.86	1	
COU2239	22271+4507	9.4	10.5	150.3	0.82	2015.74	1	
BU 1218	22281+2942	9.5	10	53.2	1.55	2015.688	1	
HU 388	22302+2228	8.4	9.1	66.3	0.61	2015.688	1	1
HO 475AB	22328+2625	9.3	9.6	305.3	1.1	2015.688	1	
HO 475BC	22328+2625	9.6	11.3	218.8	8.25	2015.688	1	2
HO 475AC	22328+2625	9.3	11.3	226.3	8.4	2015.688	1	2
BU 381	22328+3324	8.8	10	226.4	1.41	2015.74	1	
COU 141	22344+2514	10	10	206.8	1.51	2015.688	1	
A 1473	22397+5441	9.4	10	288.1	1.42	2015.833	1	
A 2099	22400+0113	8.5	9.3	164.2	0.79	2015.852	1	1
HU 494	22406+0632	9.9	9.9	333.4	0.47	2015.86	1	1
HO 296AB	22409+1433	6.1	7.2	53.8	0.55	2015.86	1	1
STF2934	22419+2126	8.6	9.5	58	1.29	2015.797	1	1
BU 710	22426+2943	9.6	9.6	249.4	0.61	2015.688	1	
STT 476A,BC	22431+4710	7.3	7	300.7	0.53	2015.74	1	
A 1474	22451+5458	9.6	9.9	16.1	0.55	2015.833	1	
A 189AB	22470+4446	8.9	9.1	26.6	0.95	2015.74	1	
HU 985	22479+1259	9.6	9.8	130.2	0.72	2015.833	1	1
HO 482AB	22514+2623	7.3	8.2	11.3	0.6	2015.86	1	1
BU 382AB	22537+4445	5.9	7.7	245.8	0.72	2015.797	1	1
A 1476	22540+3654	10.1	10.3	277.8	0.74	2015.74	1	
HU 987	22557+1547	9.2	9.7	77.3	1.11	2015.797	1	1
COU 240	22564+2257	7.7	8.8	290.7	0.75	2015.797	1	
A 200	23147+4116	8.7	9.2	83.1	0.56	2015.833	1	
BU 720	23340+3120	5.6	6.1	102.8	0.58	2015.833	1	1
A 642	23379+5806	8.8	10.1	27	0.79	2015.833	1	
A 1241AB	23380+1253	9	9.7	5	0.62	2015.833	1	
HU 1325	23401+1258	9.8	10	34.52	0.781	2015.83	1	1
A 792	23505+4703	9.6	9.6	268.5	0.63	2015.833	1	
A 796	23514+4745	8.2	10	6.9	0.68	2015.833	1	
STT 510AB	23516+4205	7.8	8.4	120.8	0.61	2015.833	1	1
BU 728AB	23522+4331	8.6	8.9	10.3	1.22	2015.833	1	

Table Notes:

1. O-C given in Tab 3
2. Direct measure (no AC computed)
3. AB=STT 531
4. AB=A1061 AB=A1061
5. Possible quadrant inversion wrt. WDS (see Fig. 5)
6. AC=STF439
7. AB=BU 880
8. Direct measure by surface adjustment (Surface algorithm in Reduc)

Speckle Interferometry of Close Visual Binaries with a 280 mm Reflector and an EM-CCD

Table 2 – Pairs observed but for which no measure was obtained

NAME	RA+DEC	MAGS		Date	N	NOTES
HU 802	00549+4924	7.8	10	2015.797	1	1
COU1860	01573+4620	9.8	9.8	2015.86	1	2
A 2018	02298+0709	9.7	9.9	2015.871	1	2
A 2333	02317+0244	9	10	2015.871	1	1
COU1224	03333+3643	10	10	2015.951	1	1
COU 151	04057+2248	9.3	9.3	2015.918	1	1
COU1394	04070+3934	9.3	9.3	2015.814	1	2,4
A 1545AB	04477+4014	8.9	10.5	2016.063	1	1
A 2701	05130+0828	9.5	9.5	2016.055	1	1
COU1537	05349+3439	9.6	9.6	2015.918	1	1
J 1093	06347+2605	9.7	10.5	2016.068	1	2
A 2458	06508+1614	9.8	10.1	2015.918	1	1
A 1061AB	06594+2514	8.9	9.1	2016.068	1	2,3
AG 331	07123+1839	9.5	9.7	2015.948	1	2
COU1979	21462+4254	9	9.4	2015.797	1	1
A 620	21545+4403	9.1	9.1	2015.797	1	1
TDT3352	22071+5411	9.9	10	2015.86	1	2
A 192	22590+4617	9.9	10	2015.86	1	1

Table 2 Notes:

1. Viewed elongated (according to the ephemerids or last measurement) but too close to be measured
2. Viewed as simple
3. AC=STF1000. Has orbit, grade=5. Ephemerids give sep=0,2'' for 2016
4. Has orbit, grade=5. Ephemerids give sep=0,24'' for 2016

Table 3 – O-C Residuals for pairs having an known orbit

HOME	RA+DEC	DATE	O-C (PA,SEP)		GRADE	REF
HLD 60	00014+3937	2015.795	-0.09	-0.2	3	Hrt2011a
BU 394AB	00308+4732	2015.862	-0.02	0.8	4	Zul1997b
A 651	00434+4726	2015.852	0	-1.4	5	USN2002
BU 232AB	00504+5038	2015.797	-0.02	0.6	3	Sca2008a
STT 20AB	00546+1911	2015.825	0	-1.2	3	Doc2014a
STF 73AB	00550+2338	2015.852	0.02	-0.6	2	Mut2010b
BU 867	01014+1155	2015.86	0.05	1.5	4	Hrt2008
STT 21	01030+4723	2015.871	0.15	-0.3	5	Hei1966
STT 515AB	01095+4715	2015.797	0.07	-2.3	4	Mut2010b
BU 235Aa,Ab	01106+5101	2015.797	-0.03	1.4	4	USN2002
BU 509	01437+0934	2015.827	-0.02	0.3	3	Hrt2010a
BU 453AB	01450+5707	2015.871	0.06	-3.9	5	Sul1984
BU 260	01532+1526	2015.825	0	-1.9	5	Cve2006e
STF 186	01559+0151	2015.825	0.02	-2.1	2	USN2007b
STF 228	02140+4729	2015.871	0.04	1.5	2	Sca2015c
A 207	02182+3920	2015.871	0.27	-10.1	4	Sca2001d
STF 248	02211+4246	2015.995	0.08	-3.5	4	Pbx2000b
STT 43	02407+2637	2015.827	0	1.5	4	Sca2001d
A 1281AB	02517+4559	2015.871	0.04	3.5	4	Hrt2014a
A 2413	02572+0153	2015.871	0.07	-2.7	3	Hrt2010a
BU 525	02589+2137	2015.827	0.11	-5.5	4	Csa1978

Table 3 concludes on next page.

Speckle Interferometry of Close Visual Binaries with a 280 mm Reflector and an EM-CCD

Table 3 (conclusion). O-C Residuals for pairs having an known orbit

NAME	RA+DEC	DATE	O-C (PA,SEP)		GRADE	REF
STF 346AB	03054+2515	2015.951	-0.08	0	3	Hei1981a
HU 1055AB	03151+1618	2015.951	0.18	-0.6	4	Hrt2000a
STF 380	03217+0845	2015.951	0.06	2.1	5	Pop1996b
A 983	03310+2937	2015.984	0.14	3.1	4	Doc2010d
STF 412AB	03344+2428	2015.951	0.01	0.9	3	Sca2002a
STF 483	04041+3931	2015.918	0.04	0.2	4	USN2006b
A 1710	04064+4325	2016.063	0.06	2.9	3	Hei1982c
STT 531AB	04076+3804	2015.918	0.29	2.7	5	Hei1986b
STT 531AB	04076+3804	2015.984	0.33	2	5	Hei1986b
STT 77AB	04159+3142	2016.063	0.03	-3.7	3	Sta1985
STF 520	04182+2248	2016.063	0.08	-1.7	3	Hrt2001b
STT 82AB	04227+1503	2015.918	0.04	-2.5	3	WSI2004a
HU 608	04262+3544	2015.918	0.01	-0.3	5	Hrt2009
STT 86	04366+1946	2015.984	0.15	-2	4	Zir2010
STF 566AB,C	04400+5328	2016.055	-0.04	2.9	4	Cve2008a
STT 95	05055+1948	2016.096	-0.05	-3.1	4	Jas1996b
STT 98	05079+0830	2015.932	-0.04	-3	2	Sca2008d
STT 124	05589+1248	2016.055	0.37	-9.8	5	Baz1988d
WOR 6	06323+5225	2016.055	-0.01	6.2	4	Hrt2009
STT 149	06364+2717	2015.918	0	-4.2	3	Hei1993d
STF 945	06404+4058	2015.918	-0.02	-1.3	4	Nov2007d
STT 159AB	06573+5825	2016.055	0.02	-0.4	3	Alz2000a
STF1037AB	07128+2713	2015.948	0.01	-0.6	2	Sca2015b
STF1037AB	07128+2713	2016.068	-0.04	-0.9	2	Sca2015b
STF1093	07303+4959	2015.948	-0.02	0.2	5	Hrt2009
STT 177	07417+3726	2016.063	0.02	8.3	3	Hei1982c
STF1196AB	08122+1739	2016.063	0	1.7	1	WSI2006b
A 1584	08531+5457	2016.096	0.04	-2.6	2	Msn2014a
STF1356	09285+0903	2016.096	0	- 1.4	2	Mut2010b
STF2799AB	21289+1105	2015.688	0.05	0.9	4	Hrt2011a
BU 75AB	21555+1053	2015.688	-0.01	1.1	2	Hei1996a
BU 1216	22202+2931	2015.688	-0.01	-4.2	5	Lin2012a
BU 1216	22202+2931	2015.797	0.01	-2.3	5	Lin2012a
HU 388	22302+2228	2015.688	0.07	5.2	4	Doc2008c
A 2099	22400+0113	2015.852	-0.02	-0.3	4	Hrt2010a
HU 494	22406+0632	2015.86	-0.02	-0.3	4	Hrt2010a
HO 296AB	22409+1433	2015.86	0.08	3.2	1	Mut2010b
STF2934	22419+2126	2015.797	-0.06	4	4	Zir2013c
HU 985	22479+1259	2015.833	0.05	-6.1	5	USN2002
HO 482AB	22514+2623	2015.86	0.05	-4.2	3	Pru2014
BU 382AB	22537+4445	2015.797	0.02	4.1	2	Sca2014a
HU 987	22557+1547	2015.797	-0.03	0.3	4	USN2007a
BU 720	23340+3120	2015.833	0.01	-1.7	4	Mut2010e
HU 1325	23401+1258	2015.83	-0.092	3.47	5	Sca2003a
STT 510AB	23516+4205	2015.833	0.01	-179.1	4	Nov2006e

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Acknowledgments

This research has made use of the Washington Double Star and 6th Orbit catalogs maintained at the U.S. Naval Observatory. Data reduction was carried out using the *Reduc* software (v 5.0) developed and maintained by F. Losse.

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Astronomical Association of Queensland Measurement of Seven Neglected Double Stars

Graeme Jenkinson

Astronomical Association of Queensland.
bluestars@iprimus.com.au

Abstract: This paper presents the results of a mid 2015 program of photographic measurements of seven southern multiple stars.

Introduction

These latest results are part of an ongoing program commenced in 2008 by the Double Star Section of the Astronomical Association of Queensland. The target stars were selected from the Washington Double Star Catalog (WDSC) and were observed in Queensland from a latitude of approximately 27° S.

Method

Once obtained with the equipment described below, the images were analysed using the astrometric double star program REDUC (Losse, 2008). Approximately 10 stacked images of each target were taken per night for seven nights and the results averaged to obtain measures of separation and position angle with sufficient confidence.

Full details of the method are given in Napier-Munn and Jenkinson (2009). Some recent work on the errors inherent in the method is described in Napier-Munn and Jenkinson (2014). As proficiency has grown in the use of this equipment with the 400mm reflector, close doubles with considerable magnitude difference between the components have been successfully measured.

Results

For all of the systems shown in Tables 2 through 8, the WDSC information is first reproduced, showing the epoch 2000 position, magnitudes, separation, PA, and the last recorded measurement. The new measurements are then given in tabular form, including the mean and standard deviation and 95% confidence limits. Any uncertainties between the images and the last recorded measurements are discussed. Finally a conclusion is given as to whether any movement of the component stars has occurred in PA or separation, based on the P-value for the t-test comparing the new mean values with the cataloged value ($P < 0.05$ is considered as evidence of change).

Summary

The images were obtained using a Meade DSI CCD camera in conjunction with an equatorially mounted 400mm F4.5 reflector. Image processing was carried out using Losse's REDUC software.

The mean 95% confidence intervals for the new measures were ± 0.944° in PA and ± 0.193" in separation. The results are summarized in Table 1.

(Continued on page 504)

Table 1. Summary of Measurements

System	Last listed measure			New measure			Comment
	PA °	Sep."	Epoch	PA °	Sep."	Epoch*	
RSS410 Scorpius	328.0	8.3	1976	323.74	8.18	2015.471	Definite change in PA
B2801AB Scorpius	225.0	10.0	1930	184.96	14.12	2015.471	Significant movement
I 1304 Scorpius	325.0	5.9	1987	326.11	6.16	2015.524	Slight movement
RST3159 Sag	102.0	4.9	1945	102.0	4.9	2015.599	No probable movement
RST1878 Norma	215.0	9.5	1971	212.96	9.02	2015.490	Slight change in PA
I 1357 Cr A	38.0	5.5	1926	36.33	6.45	2015.611	Possible slight movement
B315 Scorpius	307.0	5.2	1928	309.42	4.88	2015.471	Slight movement

* Epochs of new measures given in Besselian years as the average of the observations making up the measure

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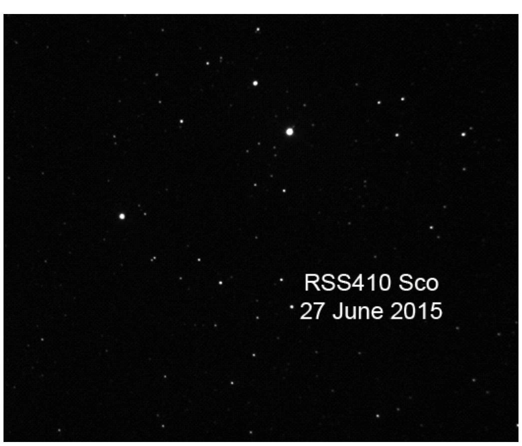
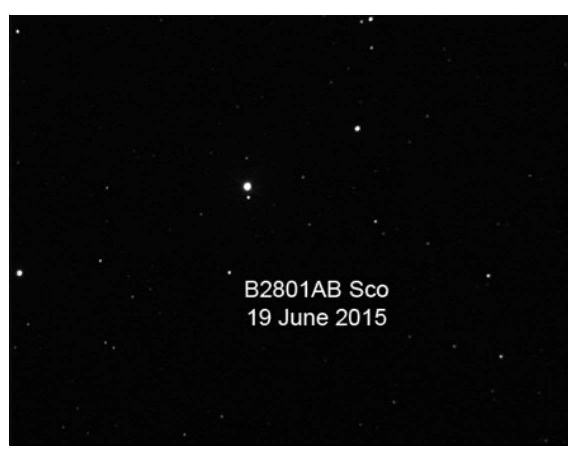
Table 2. Measurements of RSS 410

RSS410	**RA. 16 32.2**	**DEC. -32 08**	**Last Measure 1976**
Scorpius	**MAG. 8.3 & 8.78**	**PA. 328.0°**	**SEP. 8.3"**
Date	**No. images**	**PA°**	**Sep"**
07 June 2015	10	324.56	7.967
15 June 2015	10	324.77	8.021
19 June 2015	10	322.92	8.162
21 June 2015	10	323.77	8.473
27 June 2015	10	323.47	8.108
01 July 2015	10	322.19	8.443
03 July 2015	10	324.47	8.103
Mean		**323.736**	**8.182**
Standard deviation		0.950	0.199
95% CI +/-		0.879	0.184
P(t) movement		0.000	0.169
COMMENTS Definite movement in PA since the only previous measure in 1976.			

Table 3. Measurements of B 2801AB

B2801AB	**RA. 16 12.2**	**DEC. -23 55**	**Last Measure 1930**
Scorpius	**MAG. 8.0 & 14.0**	**PA. 225.0°**	**SEP. 10.0"**
Date	**No. images**	**PA°**	**Sep"**
07 June 2015	10	184.80	14.071
15 June 2015	10	184.37	14.169
19 June 2015	10	185.04	14.121
21 June 2015	10	185.53	14.139
27 June 2015	10	185.41	14.175
01 July 2015	10	185.08	14.048
03 July 2015	10	184.47	14.109
Mean		**184.957**	**14.119**
Standard deviation		0.440	0.047
95% CI +/-		0.407	0.044
P(t) movement		0.000	0.000
COMMENTS Significant movement in both axes since the original 1930 measure.			





Astronomical Association of Queensland Measurement of Seven Neglected Double Stars

Table 4. Measurements of I 1304

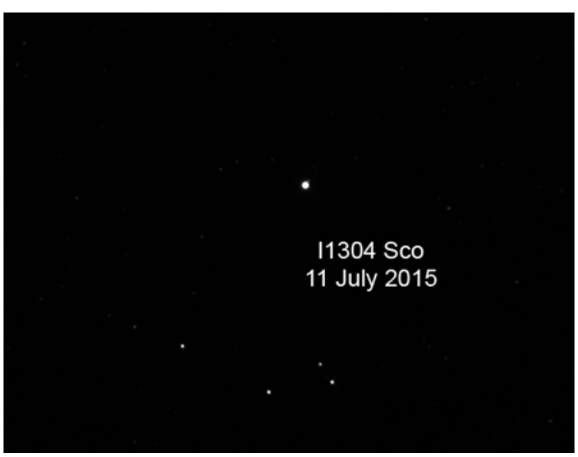
I 1304 Scorpius	RA. 16 58.3	DEC. -33 37	Last Measure 1987
	MAG. 7.16 & 13.0	PA. 325.0°	SEP. 5.9"
Date	**No. images**	**PA°**	**Sep"**
06 July 2015	11	326.30	6.062
07 July 2015	16	326.79	5.856
09 July 2015	10	326.05	5.815
11 July 2015	10	324.61	6.262
18 July 2015	10	326.60	6.728
21 July 2015	10	326.37	6.066
28 July 2015	10	326.06	6.340
Mean		**326.111**	**6.161**
Standard deviation		0.714	0.315
95% CI +/-		0.661	0.291
P(t) movement		0.006	0.071

COMMENTS
Possible very slight movement in PA since first 1925 measure.

Table 5. Measurements of RST 3159

RST3159 Sagittarius	RA. 18 10.9	DEC. -34 14	Last Measure 1945
	MAG. 9.09 & 14.1	PA. 102.0°	SEP. 4.9"
Date	**No. images**	**PA°**	**Sep"**
29 July 2015	10	100.94	4.403
04 August 2015	10	100.24	4.776
05 August 2015	10	100.11	4.547
07 August 2015	12	100.82	5.166
08 August 2015	10	101.19	5.139
11 August 2015	10	103.65	5.200
18 August 2015	10	103.62	5.225
Mean		**101.510**	**4.922**
Standard deviation		1.500	0.343
95% CI +/-		1.388	0.317
P(t) movement		0.421	0.869

COMMENTS
Little apparent movement.



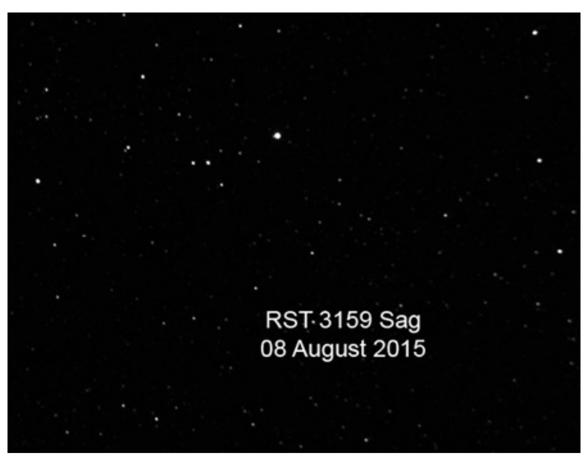


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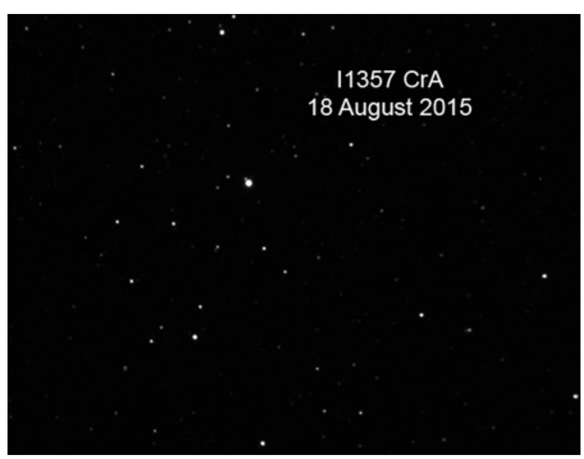
Table 6. Measurements of RST 1878

RST1878	RA. 16 09.2	DEC. -56 03	Last Measure 1971
Norma	MAG. 6.5 & 13.5	PA. 215.0°	SEP. 9.5"
Date	No. images	PA°	Sep"
15 June 2015	10	214.21	9.315
19 June 2015	10	209.61	8.875
21 June 2015	10	213.96	9.196
28 June 2015	10	213.53	9.138
01 July 2015	10	213.50	8.999
03 July 2015	10	213.38	8.967
04 July 2015	10	212.52	8.628
Mean		**212.959**	**9.017**
Standard deviation		1.569	0.227
95% CI +/-		1.451	0.210
P(t) movement		0.014	0.001
COMMENTS Probable slight change in PA.			

Table 7. Measurements of I 1357

I 1357	RA. 18 16.1	DEC. -43 16	Last Measure 1926
CrA	MAG. 9.12 & 14.8	PA. 38.0°	SEP. 5.5"
Date	No. images	PA°	Sep"
04 August 2015	10	38.61	6.511
07 August 2015	10	36.64	6.213
08 August 2015	10	35.10	6.493
11 August 2015	10	35.49	6.616
14 August 2015	10	37.85	6.502
15 August 2015	10	35.24	6.375
18 August 2015	11	35.36	6.428
Mean		**36.327**	**6.448**
Standard deviation		1.411	0.128
95% CI +/-		1.305	0.118
P(t) movement		0.020	0.000
COMMENTS Possible slight movement over the last 99 years.			



Astronomical Association of Queensland Measurement of Seven Neglected Double Stars

Table 8. Measurements of B 315

B315	RA. 16 44.9	DEC. -30 24	Last Measure 1928
Scorpius	MAG. 9.1 & 13.3	PA. 307.0°	SEP. 5.2"
Date	No. images	PA°	Sep"
07 June 2015	10	308.79	4.949
15 June 2015	10	309.25	4.642
19 June 2015	10	310.36	4.869
27 June 2015	10	308.89	4.777
28 June 2015	10	309.83	4.752
01 July 2015	10	309.18	5.262
03 July 2015	10	309.66	4.944
Mean		**309.423**	**4.885**
Standard deviation		0.559	0.199
95% CI +/-		0.517	0.184
P(t) movement		0.000	0.006
COMMENTS Slight increase in PA and decrease in separation appear consistent with the two previous measures.			

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ACKNOWLEDGEMENTS

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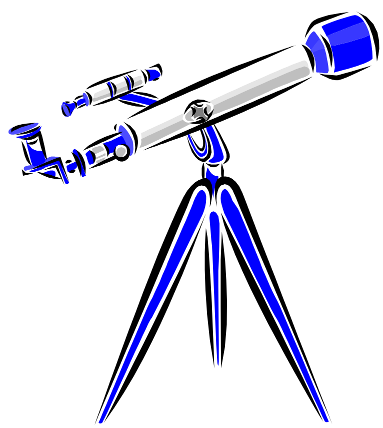

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