The Webb Deep-Sky Society

Double Star Section Circular No 26

Contents

This circular has been edited and arranged by R.W.Argyle, Director of the Webb Society Double Star Section.
E-mail: rwa@ast.cam.ac.uk

On-line copies of Double Star Section Circulars Nos 1 to 25 are available on the following website:
http://www.webbdeepsky.com/

In case of difficulty, contact the Webb Society Webmaster, James Whinfrey at: james.whinfrey@gmail.com

For further information about the Webb Society contact:

In the USA and Canada: J. E. Isles, 10575 Darrel Drive, Hanover, Michigan 49241, U.S.A.
E-mail: j_isles@yahoo.com

In the UK: D. J. Miles, 10 Rosewood Gardens, Clanfield, Waterlooville, Hampshire, PO8 0LT, England.
E-mail: donjmiles@googlemail.com

Editorial

The number of measures included in these Circulars is now 55943

Observer	WDS code	Pairs	Measures	Method/source
R. W. Argyle	ARY	78	251	RETEL micrometer
J.- F. Courtot	CTT	61	180	RETEL, homemade & Méca-Precis micrometers
A. Debackère	DBR	32	41	CCD imaging
G. Jenkinson	JNK	11	76	CCD imaging
W. Knapp	KPP	50	76	CCD imaging and data mining
M. Scardia	SCA	82	294	Darbinian micrometer
N. Webster	WBT	184	184	Graticule eyepiece
TOTALS		498	1102	

Bob Argyle,
2018 July

Useful sites

The following websites also contain a considerable amount of interesting material for the serious double star observer and no claim is made for the completeness of the list. If anyone knows of any others please contact me:

The Washington Double Star catalogue - the complete reference for visual double stars - updated nightly. The site also contains the Sixth Catalogue of Visual Binary Star Orbits and much more at `http://ad.usno.navy.mil/wds`

Journal for Double Star Observations (`www.jdso.org`)

Observations et Travaux (in French). A journal published by the Société Astronomique de France which often contains double star observations. The SAF Double Star Commission has a website at `http://astrosurf.com/saf`

El Observador de Estrellas Dobles (in Spanish)
(`www.elobservadordeestrellasdobles.wordpress.com`)

Observatori Astronòmic del Garraf (`www.oagarraf.net`)

Il Bollettino delle Stelle Doppie (in Italian)
(`https://sites.google.com/site/ilbollettinodellestelledoppie/`)

The Double Star Section of the Astronomical Society of Southern Africa
(`http://assa.ac.za/sections/deep-sky/doublestars/news-and-articles`)

In addition the Stelle Doppie Double Star Database run by Gianluca Sordiglioni allows the WDS catalogue to be quizzed with various search parameters. You can get a user name and password at `stelledoppie.goaction.it`

Acknowledgements

Much of the work presented here has made use of the Washington Double Star Catalogue maintained at the U.S. Naval Observatory (see above).

MICROMETER MEASURES OF DOUBLE STARS IN 2017

Bob Argyle, Lyndhurst, Ely Road, Waterbeach, Cambridge, CB25 9NW, UK

E-mail: rwa@ast.cam.ac.uk

Introduction

In this publication, the author presents his micrometric measurements which were mostly made between 2016.0 and 2017.0. A small number of pairs have mean epochs outside this range either due to delay in getting a sufficient number of observations to form a mean, or which were inadvertently left out of earlier papers. The 8-inch f/14 Cooke refractor at the Observatories of the University of Cambridge has again been used for this work. It is equipped with a RETEL micrometer at a power of x450. Using a Barlow lens, the screw constant is $12''.45$ per revolution which allows an equivalent reading accuracy of $\pm 0''.025$. The scale and orientation of the micrometer is derived at the beginning and end of each observing session using a number of fixed, wide pairs with astrometry from the Hipparcos satellite.

Measurements are arranged as usual (see Courtot & Argyle[1] for more details). Table 1 gives the name of the pairs using the WDS nomenclature[2] with the following codes and contains 331 measurements of 114 systems:

FRK	Franks, W. S.	SHJ	South & Herschel	FYM	Fay, M.
H	Herschel, W.	STF	Struve, F. G. W.	STT	Struve, O.
STTA	Struve, O. Appendix	KNT	Knott, G.	STFA	Struve, W. Appendix
S	South, J.				

The protocols followed here for measuring are very similar to earlier publications and consist basically of multiple double measures of separation (usually four or five) and repeated measures of position angle (usually four to six) taken on several different evenings taken together to get the final mean values of position angle and angular distance.

Table 3 gives the residuals from known orbits. The orbital elements come from the online version of the 6th USNO Catalogue of Orbits of Visual Binary Stars[3].

Acknowledgements

The author is grateful to Mr. T. Dobner, consulting engineer, for his work and support in keeping the telescope and dome operational, and to Mr I. Whittingham for maintaining the RA drive system which he developed for the telescope. Much of the work presented here has made use of the Washington Double Star Catalogue maintained at the U.S. Naval Observatory.

References

1). Courtot, J.-F. & Argyle, R. W., *Webb Society Double Star Section Circular*, **12**, 1, 2004
2). Hartkopf, W. I., Mason, B. D. & Worley C. E.: Sixth Catalog of Orbits of Visual Binary Stars. Astrometry Department, U.S. Naval Observatory. http://ad.usno.navy.mil/ad/wds/hmw5.html
3). Mason, B. D., Wycoff, G. L. & Hartkopf, W. I. : Washington Double Star Catalogue (References and discovery codes) http://as.usno.navy.mil/ad/wds/wdsnewref.txt

Table 1: Measures of double stars

Pair	Comp	RA	Dec	V_a	V_b	PA (°)	Sep (″)	Epoch (Julian)	N	Obs.
STF73	AB	00550	+2338	6.12	6.54	333.7	1.14	2017.222	4	ARY
STF163	AB	01513	+6451	6.80	9.13	37.4	34.94	2017.014	3	ARY
STF202	AB	02020	+0246	4.10	5.17	263.8	1.89	2017.378	5	ARY
STF572	AB	04385	+2656	7.36	7.21	189.4	4.40	2017.126	2	ARY
S461	AB,C	05017	+2640	6.85	8.25	159.1	78.31	2017.126	2	ARY
STT98		05079	+0830	5.76	6.67	290.6	1.02	2017.161	4	ARY
STTA61		05091	+2947	6.72	8.49	244.6	69.16	2017.126	2	ARY
STF645	A,BC	05098	+2902	6.04	9.11	28.5	11.32	2017.126	2	ARY
WNC2	A,BC	05239	−0052	6.87	6.96	158.5	3.19	2017.093	2	ARY
STF668	A,BC	05145	−0812	0.3	6.8	203.5	9.43	2017.156	3	ARY
STF728		05308	+0557	4.44	5.75	43.7	1.25	2017.220	2	ARY
STF3115		05491	+6248	6.55	7.51	336.5	0.85	2017.784	2	ARY
STT545	AB	05597	+3713	2.60	7.2	304.8	4.16	2017.231	4	ARY
STF941	AB	06387	+4135	7.25	8.17	268.1	1.95	2017.288	2	ARY
BU1008		06149	+2230	3.52	6.15	257.5	1.78	2017.220	3	ARY
STF1037	AB	07128	+2713	7.24	7.27	303.8	0.92	2017.208	2	ARY
STF1110	AB	07346	+3154	1.93	2.97	53.3	5.37	2017.247	9	ARY
STF1110	AC	07346	+3154	1.93	9.83	163.0	69.74	2017.241	3	ARY
STT174		07359	+4302	6.67	8.26	91.7	1.91	2017.237	3	ARY
STTA87		07389	+4229	7.59	7.78	357.5	61.57	2017.223	3	ARY
STF1196	AB	08122	+1739	5.30	6.25	15.8	1.20	2017.211	5	ARY
STF1196	AB-C	08122	+1739	4.92	6.25	66.4	5.79	2017.211	5	ARY
STF1273	AB,C	08468	+0625	3.49	6.66	309.1	2.93	2017.220	3	ARY
STF1276	AB	08472	+1110	8.32	8.56	353.1	12.65	2017.210	2	ARY
STF1283		08499	+1450	7.66	8.45	122.9	16.37	2017.220	3	ARY
STF1356		09285	+0903	5.69	7.28	114.1	0.98	2017.223	2	ARY
STT215		10163	+1744	7.25	7.46	175.2	1.51	2017.369	2	ARY
STF1523	AB	11182	+3132	4.33	4.80	165.5	1.94	2017.394	6	ARY
STF1536	AB	11239	+1032	4.06	6.71	97.2	2.08	2017.375	3	ARY
STF1547	AB	11317	+1422	6.33	9.14	332.0	15.56	2017.349	3	ARY
STT235	AB	11323	+6105	5.69	7.55	45.8	0.90	2017.511	3	ARY
STF1552	AB	11347	+1648	6.26	7.31	208.8	3.48	2017.349	3	ARY
STF1552	AC	11347	+1648	6.26	9.77	235.0	62.84	2017.349	3	ARY
STF1555		11363	+2747	6.41	6.78	148.7	0.79	2016.394	3	ARY
STF1565		11396	+1900	7.26	8.41	305.6	21.80	2016.369	2	ARY
STF1573		11492	+6720	7.50	8.30	180.0	10.92	2017.511	3	ARY
STF1575		11520	+0850	7.43	7.89	209.2	30.74	2015.839	2	ARY
STF1670	AB	12417	−0127	3.48	3.53	0.7	2.57	2017.411	6	ARY
STF1740		13237	+0243	7.13	7.39	74.7	26.05	2016.420	2	ARY
STF1770		13377	+5043	6.93	8.18	128.0	1.81	2017.511	3	ARY
STF1846	AB	14282	−0214	4.92	10.02	112.5	4.81	2015.918	2	ARY
STF1888	AB	14514	+1906	4.76	6.95	300.5	5.37	2017.523	9	ARY
STF1937	AB	15232	+3017	5.64	5.95	231.0	0.56	2017.585	2	ARY
STF1938	BaBb	15245	+3723	7.09	7.63	4.4	2.21	2017.595	5	ARY
STT298	AB	15360	+3948	7.16	8.44	187.3	1.32	2017.577	3	ARY

STT298	AC	15360	+3948	7.16	7.75	328.2	120.37	2017.562	2	ARY
STF1954	AB	15348	+1032	4.17	5.16	173.3	4.02	2017.599	4	ARY
STF2007	AB	16060	+1319	6.89	7.98	322.0	38.43	2013.604	4	ARY
STF2021	AB	16133	+1332	7.43	6.49	358.0	3.99	2017.617	3	ARY
STF2032	AB	16147	+3352	5.62	6.49	239.4	7.22	2016.574	2	ARY
STF2052	AB	16289	+1825	7.69	7.91	120.4	2.37	2017.629	2	ARY
STF2055	AB	16309	+0159	4.15	5.15	43.8	1.53	2017.556	4	ARY
STF2084		16413	+3136	2.95	5.40	121.4	1.56	2017.595	5	ARY
STF2130	AB	17053	+5428	5.66	5.69	2.9	2.47	2017.833	5	ARY
STF2180		17290	+5052	7.79	8.06	261.3	3.00	2017.797	3	ARY
STF2194	AB	17411	+2431	6.51	9.28	7.1	16.37	2017.615	2	ARY
STF2232		17503	+2517	6.71	8.85	139.8	6.23	2017.629	2	ARY
STF2259		17590	+3003	7.27	8.44	276.7	19.57	2017.592	2	ARY
STF2262	AB	18031	−0811	5.27	5.86	290.5	1.70	2017.612	3	ARY
STF2272	AB	18055	+0230	4.22	6.17	124.3	6.35	2017.580	6	ARY
STF2382	AB	18443	+3940	5.15	6.10	345.7	2.18	2017.873	3	ARY
STF2383	CD	18443	+3940	5.25	5.38	77.3	2.36	2017.873	3	ARY
STF2487	AB	19138	+3909	4.38	8.58	80.9	28.36	2017.873	3	ARY
H 1 93	AB	20017	−0012	7.67	8.39	206.4	1.76	2017.755	2	ARY
STTA198	AB	20066	+0735	7.12	7.55	185.4	64.55	2017.755	2	ARY
STT413	AB	20474	+3629	4.73	6.26	5.5	1.00	2017.768	2	ARY
STT432		21143	+4109	7.78	8.05	117.1	1.24	2016.545	3	ARY
STF2758	AB	21069	+3845	5.20	6.05	153.3	31.46	2017.895	5	ARY
AGC13	AB	21148	+3803	3.83	6.57	189.7	1.05	2017.876	3	ARY
STT434	AB	21190	+3945	6.67	9.93	123.2	24.47	2017.189	3	ARY
STF2822	AB	21441	+2845	4.75	6.18	321.6	1.68	2017.798	4	ARY
SHJ345	AB	22266	−1645	6.29	6.39	81.4	1.29	2017.810	4	ARY
STF2909	AB	22288	−0001	4.34	4.49	159.8	2.35	2017.819	6	ARY
STF2944	AB	22478	−0414	7.30	7.68	306.9	1.79	2017.404	2	ARY
STF2944	AC	22478	−0414	7.30	8.58	84.7	60.57	2017.404	2	ARY
STF3042		23519	+3753	7.62	7.75	267.8	5.81	2016.995	3	ARY
STF3050	AB	23595	+3343	6.46	6.72	343.4	2.40	2017.987	3	ARY
STF3062		00063	+5826	6.42	7.32	1.4	1.73	2017.955	2	ARY

Table 2: Residuals from known orbits

Pair	ADS	Residual(O−C) PA(°)	Sep (″)	Orbit	Period (yrs)	Date	Grade
STF3062	61	−0.1	+0.18	Söderhjelm	106.7	1999	2
STF73	755	−1.0	−0.01	Muterspaugh	167.51	2010	2
STF202	1615	+2.0	+0.06	Scardia	3267.49	2015	4
STT98	3711	+3.2	+0.06	Scardia	197.45	2008	2
WNC2	3991	0.0	+0.07	Rica	923	2013	5
STF728	4115	−0.5	−0.09	USNO	613.39	1999	4
STF3115	4376	+6.2	+0.10	Hartkopf	1503.7	2013	5
BU1008	4841	+4.7	+0.17	Baize	473.7	1980	5
STF1037	5871	−0.8	+0.02	Scardia	118.35	2015	2
STF1110	6175	−0.2	+0.17	Docobo	459.8	2014	3

STF1196 AB	6605	+3.0	+0.07	WSI	59.582	2006	1
STF1196 AB-C	6650	+1.1	−0.14	Heintz	1115	1996	4
STF1273	6993	+0.1	+0.11	Drummond	589	2014	4
STF1356	7390	+2.3	+0.13	Muterspaugh	117.97	2010	2
STF1523	8119	+1.6	−0.02	Mason	59.878	1995	1
STF1536	8148	+3.8	−0.08	Söderhjelm	186	1999	2
STF1555	8231	−1.4	+0.10	Docobo	916	2007	4
STF1670	8630	−0.6	−0.04	Scardia	169.014	2007	2
STF1888	9413	+0.8	−0.06	Söderhjelm	151.6	1999	2
STF1937	9619	−0.8	+0.07	Muterspaugh	41.63	2010	1
STF1938	9626	+1.1	−0.04	Kiyaeva	265	2014	2
STT298	9716	+1.1	+0.11	Söderhjelm	55.6	1999	1
STF1954	9701	+2.0	+0.05	WSI	1038	2004	4
STF2021	9969	+1.3	−0.07	Hopmann	1354	1964	4
STF2032	9979	+0.9	0.00	Raghavan	726	2009	4
STF2052	10075	+2.0	−0.06	Scardia	230.06	2015	2
STF2055	10087	+0.6	+0.11	Heintz	129	1993	2
STF2084	10157	+1.2	+0.25	Söderhjelm	34.45	1999	1
STF2130	10345	+2.7	−0.08	Prieur	812	2012	4
STF2262	11005	+2.4	+0.19	Söderhjelm	257	1999	3
STF2272	11046	+1.1	−0.12	Eggenberger	88.379	2008	1
STF2382	11635	+0.7	−0.14	WSI	1725	2004	4
STF2383	11635	+2.4	−0.03	Docobo	724.307	1984	4
STT413	14296	+7.1	+0.08	Rabe	391.3	1948	4
STF2758	14636	+1.5	−0.26	PkO	678	2006	4
AGC13	14787	−2.8	+0.08	Muterspaugh	49.63	2010	1
STF2822	15270	−2.3	+0.18	Heintz	789	1995	4
SHJ345	15934	+9.1	−0.01	Hale	3500	1994	4
STF2909	15971	+2.2	+0.11	Scardia	486.7	2010	3
STF2944	16270	+1.4	−0.02	Zirm	1160.28	2007	4
STF3050	17149	+2.1	−0.04	Hartkopf	717	2011	4

MICROMETRIC MEASUREMENTS OF VISUAL DOUBLE STARS (VI LIST)

Marco Scardia, I.N.A.F. - Osservatorio Astronomico di Brera - Merate, Italy and
C2PU - Observatoire de la Côte d'Azur - Plateau de Calern, France

Abstract

The results of 294 micrometric measurements of 82 binary stars made in 1988 at La Silla Observatory with the GPO astrograph are given.

Procedure

Between 1986 and 1993 I carried out several missions at the ESO Observatory in La Silla (Chile) to measure the double stars of the southern sky. The instrument used was the G.P.O. astrograph with a diameter of 40 cm and a focal length of 4 metres. In Scardia[1], I briefly describe the changes I had to make to the instrument, an astrograph, to make it usable for direct visual observation of binary stars. The filar micrometer and the filter used to reduce the secondary spectrum of the astrographic objective are the same as my previous missions in La Silla. The only change made in this fourth mission was the replacement of the Mitutoyo micrometer screw of the filar micrometer with an equivalent one. In Scardia[2], it is possible to read some of my considerations on the quality of the G.P.O. intrument and of the magnificent sky of La Silla relative to the visual observation of binary stars. Table 1 shows the observations, whilst Table 2 presents the (O-C)s calculated with the orbital elements reported in the Orbits Catalog 6 (OC6) of the U.S. Naval Observatory in Washington (U.S.A.) . An asterisk indicates that an orbit was calculated for that star and the (O-C)s are in Table 2.

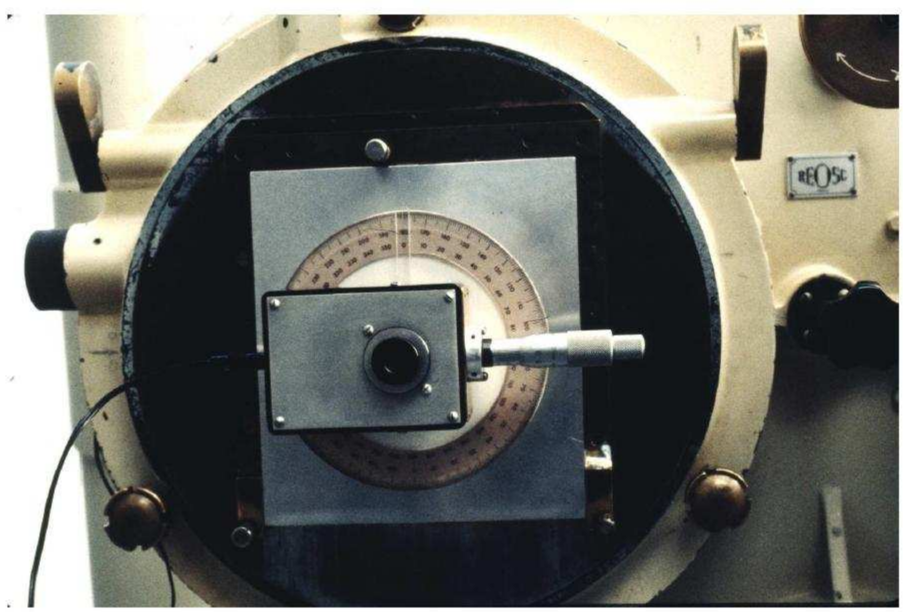

Figure 1: Darbinian filar micrometer on 40-cm GPO telescope at La Silla (M. Scardia)

Table 1: Measures of double stars

WDS	Name		ADS	1980+ (Julian)	ρ	θ	Δmag.	n
08050−3419	B 1579			8.285	0.85	316.8	0.1	4
08050−6023	MLO 2			8.290	1.56	353.4	1.0	4
08098−4238	DUN 63			8.297	5.49	81.5	1.2	4
08173−0522	A 337		6719	8.294	0.38	86.9	0.4	4*
08250−4246	RST 4888	AB		8.279	0.48	111.7	0.5	4
08291−4756	HJ 4104	AB		8.289	3.32	243.9	2.0	5
08391−2240	BU 208	AB	6914	8.286	0.93	21.9	1.4	5*
08421−1726	HO 529		6944	8.294	0.26	187.7	0.0	4
08451−5843	RMK 9	AB		8.300	4.00	291.8	0.2	4
08563−5243	R 87			8.349	2.45	336.4	2.6	1
09017−5211	HJ 4165			8.349	0.80	131.2	1.3	1
09125−4337	FIN 317	Aa,Ab		8.327		Round		4
09125−4337	HJ 4188	AB		8.301	2.72	280.6	0.8	4
09161−0821	BU 212		7270	8.318	1.51	202.7	0.6	4
09333−5758	R 123			8.304	1.85	33.0	0.2	4
09427−5550	R 129			8.349	3.19	296.0	0.2	1
10050−5119	HU 1594			8.281	0.42	289.1	0.4	4*
10062−4722	I 173			8.349	0.90	0.0	1.8	1*
10068−2443	BU 217		7644	8.303	1.94	127.4	0.1	4
10074−1943	BU 218		7647	8.291	0.58	137.3	0.5	4
10191−6441	HJ 4306			8.303	2.31	133.1	0.0	4
10260+0256	A 2570		7769	8.310	0.36	307.7	0.0	4*
10361−2641	BU 411		7846	8.276	1.16	313.5	0.8	4*
10468−4925	R 155			8.293	1.91	49.8	3.5	4*
10494−5919	R 161			8.336	1.06	288.6	1.2	4
11151−3929	SEE 128			8.322		Round		3
11165−4553	HJ 4423			8.313	2.55	275.6	0.4	4
11170−5537	FIN 181			8.305	0.29	159.9	–	6
11175−5906	R 163	A,BC		8.295	1.59	57.1	0.7	4
11175−5906	RST 4472	BC		8.314	0.26	36.1	0.5	4
11268−5310	I 883			8.310		Round		4
11336−4035	I 78			8.279	0.88	96.4	0.0	4
11357−7012	DON 490			8.326	0.68	64.1	0.5	4
11383−6322	I 422	AB		8.339	0.39	110.5	0.3	3*
11406−6234	CPO 11	AB		8.323	2.65	220.1	0.5	4
11550−5606	HLD 114			8.316	3.57	173.9	0.6	4
11554−4154	I 80			8.345	1.36	95.1	0.3	2
11589−2555	I 510		8371	8.325		Round		4
12158−2321	BU 920		8481	8.301	1.60	298.7	1.3	4*
12178−3606	R 193			8.345		Round		2
12283−6146	CPO 12	A,BC		8.300	2.01	202.7	0.8	4*
12283−6146	RST 4499	BC		8.291		Round		2*
12417−0127	STF 1670	AB	8630	8.274	2.89	287.7	0.1	4*
12421−5446	FIN 200			8.336	0.41	265.3	0.4	4
12564−0057	STT 256		8708	8.341	1.06	94.9	0.3	4*

13117−2633	FIN 305			8.295	0.21	99.6		4∗
13134−5042	I 1227			8.314	0.26	206.1	0.3	4∗
13229−4757	SLR 18	AB		8.321	0.75	238.5	0.4	4
13261−3233	B 249			8.295	0.6	302.9	1.6	1
13343−0019	STF 1757	AB	8949	8.275	2.21	118.1	0.9	4∗
13343−0837	BU 114		8950	8.346	1.39	164.1	0.3	2
13423−3359	HJ 4608			8.323	4.38	186.7	0.1	4
13520−3137	BU 343	AB		8.338	0.47	359.8	1.0	3∗
13550−0804	STF 1788	AB	9053	8.317	3.54	96.9	0.9	4∗
14046−3539	I 941			8.316		Round		3
14063−2635	BU 938		9106	8.305	0.24	129.8	0.0	2
14153+0308	STF 1819	AB	9182	8.337	0.92	223.3	0.1	4∗
14247−1140	STF 1837		9254	8.342	1.39	278.4	1.5	4∗
14310−0548	RST 4529			8.309	0.27	1.4	0.0	2∗
14418−2942	BU 345	AB	9344	8.297	0.90	286.2	0.4	4
14485−1720	BU 346		9387	8.292	2.37	272.4	0.6	4
14493−1409	BU 106	AB	9396	8.304	1.80	359.8	0.9	3-5∗
14545−3921	I 1578			8.294	0.24	359.1	0.3	4
14565−4753	HJ 4715			8.281	2.09	275.9	0.8	4
14587−2739	BU 239		9453	8.278	0.61	350.5	0.4	4∗
15051−4703	HJ 4728			8.317	1.53	68.1	0.2	4
15185−4753	HJ 4753	AB		8.322	1.11	130.5	0.1	4∗
15197−2416	HJ 4756		9586	8.332	0.63	266.0	0.3	4∗
15226−4755	SLR 20			8.334	0.96	49.2	0.4	2∗
16044−1122	STF 1998	AB	9909	8.278	0.84	35.1	0.0	4∗
16077−3802	COO 193			8.324	1.87	188.6	0.1	3
16256−2327	H 2 19	AB	10049	8.341	2.96	339.2	0.5	4
17104−1544	BU 1118	AB	10374	8.321	0.53	252.6	0.5	4∗
17156−1018	BU 957		10421	8.321	0.38	195.7	0.1	4∗
17157−0949	A 2592		10423	8.325	0.38	217.5	0.5	4∗
17240−0921	RST 3972	Aa,Ab		8.311		Round		4∗
17533−3444	BU 1123			8.338	0.34	238.9	0.0	4∗
17534−3454	SEE 342			8.346	0.45	221.6	0.3	2∗
18031−0811	STF 2262	AB	11005	8.338	1.78	277.0	0.6	4∗
18068−4325	HJ 5014			8.335	1.59	12.2	0.1	4∗
19064−3704	HJ 5084			8.350	1.3	123.5	0.3	1∗
19172−6640	GLE 3			8.341	0.49	312.8	0.5	4∗

Table 2: Residuals from known orbits

WDS	Name		ADS	Orbit/date	Period (years)	Grade	Residual(O−C) $\rho('')$	$\theta(^\circ)$
08123−0504	A 337		6719	Tok2014a	207	4	−0.05	−0.5
08348−2219	BU 208	AB	6914	Hei1990c	123.0	3	−0.05	−3.9
10050−5119	HU 1594			Tok2015c	134.51	3	+0.10	−0.6
10062−4722	I 173			Sca2008e	202.7	4	+0.08	+2.5
10260+0256	A 2570		7769	Zir2014a	311	4	+0.03	+1.4
10361−2641	BU 411		7846	Tok2014a	158.5	3	−0.05	−2.5

10468−4925	R 155			Tok2014a	149.3	4	−0.03	+0.9
11383−6322	I 422	AB		Zas2009	285.4	5	+0.03	−1.2
12158−2321	BU 920		8481	FMR2012g	873.041	5	−0.08	−2.2
12283−6146	CPO 12	A,BC		USN2002	2520	5	−0.04	+0.2
12283−6146	RST 4499	BC		Tok2014a	2501	3	(0.186	123.3)
12417−0127	STF 1670	AB	8630	Sca2007c	169.104	2	−0.14	−0.8
12564−0057	STT 256		8708	Zir2015a	605	4	+0.08	−1.4
13117−2633	FIN 305			Doc2013d	18.915	2	+0.04	−2.9
13134−5042	I 1227			Zir2013d	100.88	3	+0.07	+3.0
13343−0019	STF 1757	AB	8949	Hei1988d	461	4	−0.02	+0.3
13520−3137	BU 343	AB		Tok2014a	280	4	−0.07	−2.0
13550−0804	STF 1788	AB	9053	Hop1970	2613	5	+0.11	+1.2
14153+0308	STF 1819	AB	9182	Sca2012b	223.5	2	+0.05	−0.5
14247−1140	STF 1837		9254	Zir2015a	1850	5	+0.14	−1.3
14310−0548	RST 4529			Doc2000b	22.98	2	−0.01	−2.5
14493−1409	BU 106	AB	9396	Zir2015a	614	5	−0.10	−1.4
14587−2739	BU 239		9453	Lin1998a	427.19	4	+0.04	−1.9
15185−4753	HJ 4753	AB		Zir2015a	772	5	−0.02	−1.0
15197−2416	HJ 4756		9586	Zir2008	541.60	5	−0.03	−1.2
15226−4755	SLR 20			Tok2015c	429.60	4	−0.05	+1.4
16044−1122	STF 1998	AB	9909	Doc2009g	45.90	1	+0.03	−1.6
17104−1544	BU 1118	AB	10374	Doc2007d	87.58	2	+0.11	−1.4
17156−1018	BU 957		10421	Tok2015c	90.33	3	−0.05	−3.2
17157−0949	A 2592	AB	10423	Tok2015c	157.60	3	+0.03	+0.6
17240−0921	RST 3972	Aa,Ab		Sod1999	15.0	2	(0.135	318.3)
17533−3444	BU 1123			Doc2017l	676.3		+0.09	+3.9
17534−3454	SEE 342			Alz2009b	700	5	+0.06	−0.4
18031−0811	STF 2262	AB	11005	Sod1999	257	3	−0.10	−0.3
18068−4325	HJ 5014			Ary2001a	450	4	−0.08	−0.7
19064−3704	HJ 5084			Hei1986b	121.76	2	−0.01	−2.5
19172−6640	GLE 3			Doc2007d	156.8	3	−0.00	−1.1

References

1. Scardia, M., 1989, Ap. J. Suppl. Ser. **71**, 647
2. Scardia, M., 1990, The Messenger No. **61**, 36

MICROMETRIC MEASURES OF DOUBLE STARS IN 2017

Jean-François Courtot, Chaumont, France

E-mail: jeff6bwo@yahoo.fr

Introduction

The measurements presented here have been made during 2017 using two different telescopes: the usual homemade 205-mm (8-inch) Newtonian (N) and either a Retel filar micrometer (F) at a power of x508 or a Lyot double-image micrometer (L) at x 464, and a 279-mm (11-inch) Schmidt-Cassegrain telescope (S) at a power of x 430 and a homemade filar micrometer (Fh). This setup is described in Ref 1. The transit method (TM) has also been used on occasion. The measurement procedures have been outlined in previous circular DSSC 23 (Ref. 2). Further indications on some observed peculiarities with double-image micrometers can be found also in DSSC 24-25 (Ref. 3-4). Measurements have been arranged as usual in Table 1. Table 2 gives a short comment on each measured pair whilst residuals O-C with recently computed orbits are to be found in Table 3.

Table 1 - Measures

Pair	Comp	RA	Dec	V_a	V_b	PA (°)	Sep (″)	Epoch (Julian)	N	Obs.	Method
STF61		00499	+2743	6.3	6.3	295.6	4.20	2017.016	1	CTT	N/F
STF186		01559	+0151	6.8	6.8	72.3	0.71	2017.055	1	CTT	N/L
STF202	AB	02020	+0246	4.1	5.2	263.0	1.88	2017.060	1	CTT	N/L
STF412	AB	03344	+2428	6.6	6.9	354.3	0.76	2017.077	4	CTT	N/L
STF550	AB	04320	+5355	5.8	6.8	309.4	10.34	2017.079	1	CTT	N/L
BU1008		06149	+2230	3.5	6.2	256.1	1.83	2017.136	2	CTT	S/Fh+N/L
STF982	AB	06546	+1311	4.7	7.7	142.8	7.24	2017.172	3	CTT	S/Fh+N/L
STF1110	AB	07346	+3153	1.9	3.0	53.0	4.96	2017.219	4	CTT	S/Fh+N/L
STF1110	AC	07346	+3153	1.9	9.8	162.7	70.60	2017.240	3	CTT	S/Fh
STF110	BC	07346	+3153	3.0	9.8	167.2	72.28	2017.246	3	CTT	S/Fh
STF1126	AB	07401	+0514	6.6	7.0	175.6	0.87	2017.198	4	CTT	N/L
STF1224	A-BC	08267	+2432	6.9	7.5	52.1	5.59	2017.246	3	CTT	S/Fh
STF1291	AB	08542	+3035	6.1	6.4	309.8	1.58	2017.211	4	CTT	N/L
STF1289		08548	+4335	8.2	8.9	6.8	3.61	2017.282	3	CTT	S/Fh
BU408		08590	+6326	7.4	9.6	345.8	2.78	2017.283	3	CTT	S/Fh
STF1321	AB	09144	+5241	7.8	7.9	97.9	17.28	2017.266	3	CTT	S/Fh
STT199	AB	09207	+5116	6.2	10.0	140.9	5.80	2017.309	3	CTT	S/Fh
STF1338	AB	09210	+3811	6.7	7.1	311.7	1.10	2017.265	4	CTT	S/Fh+N/L
STT229		10480	+4107	7.6	7.9	255.5	0.64	2017.266	3	CTT	S/Fh
STF1492		10576	+3039	8.0	10.2	165.2	21.57	2017.319	4	CTT	S/Fh
STTA108	AB	11125	+3549	6.5	7.3	68.1	161.68	2017.354	2	CTT	S/Fh+TM
STF1523	AB	11182	+3132	4.3	4.8	164.1	1.94	2017.340	1	CTT	N/L
STF1543	AB	11291	+3920	5.4	10.7	354.0	5.40	2017.281	4	CTT	S/Fh
STT235	AB	11323	+6005	5.7	7.6	42.8	0.93	2017.515	1	CTT	S/Fh
STF1573		11492	+6720	7.5	8.3	177.4	11.17	2017.363	2	CTT	S/Fh
STF1579	AB-C	11551	+4629	6.7	8.3	40.0	3.80	2017.384	3	CTT	S/Fh
STF1579	AB-D	11551	+4629	6.7	7.0	113.4	63.70	2017.388	3	CTT	S/Fh
STF1645		12281	+4448	7.5	8.1	156.4	9.83	2017.401	3	CTT	S/Fh

STT257		12567	+4537	8.5	9.6	352.8	13.02	2017.398	3	CTT	S/Fh
BU799	AB	13048	+7302	6.6	8.5	265.1	1.39	2017.414	2	CTT	S/Fh
STF1768	AB	13375	+3618	5.0	7.0	95.4	1.67	2017.426	4	CTT	S/Fh
BU802		13486	+4821	7.6	11.8	224.8	3.95	2017.394	4	CTT	S/Fh
STT274		14067	+3447	7.1	10.5	52.7	12.58	2017.425	1	CTT	S/Fh
STF1835	A-BC	14234	+0827	5.0	6.8	195.1	6.14	2017.459	4	CTT	N/F
STF1864	AB	14407	+1625	4.9	5.8	111.8	5.50	2017.461	3	CTT	S/Fh+N/F
STF1864	AC	14407	+1625	4.9	10.6	163.7	128.76	2017.444	2	CTT	N/F
STF1888	AB	14514	+1906	4.8	7.0	300.7	5.60	2017.457	4	CTT	N/F
STF1909		15038	+4739	5.2	6.1	76.1	0.61	2017.481	4	CTT	S/Fh
STF1919		15127	+1917	6.7	7.4	10.6	23.36	2017.450	2	CTT	N/F
STF1938	BaBb	15245	+3723	7.1	7.6	3.3	2.28	2017.472	4	CTT	S/Fh+N/F
STF1965		15394	+3638	5.0	5.9	303.9	6.52	2017.525	2	CTT	S/Fh
BU627	A-BC	16492	+4559	4.8	8.5	42.8	2.06	2017.563	4	CTT	S/Fh
STF2118	AB	16564	+6502	7.1	7.3	66.3	1.00	2017.528	2	CTT	S/Fh
STF2140	AB	17146	+1423	3.5	5.4	104.5	4.83	2017.588	4	CTT	S/Fh
STF2180		17290	+5052	7.8	8.1	260.3	3.06	2017.634	4	CTT	S/Fh
STF2310		18206	+2248	6.8	10.0	234.9	5.08	2017.629	4	CTT	S/Fh
STT359		18355	+2336	6.4	6.6	6.3	0.76	2017.595	4	CTT	S/Fh
HJ2850		19008	+2318	8.8	9.7	274.3	2.73	2017.643	4	CTT	S/Fh
STF2534		19277	+3632	8.2	8.4	62.8	6.95	2017.654	4	CTT	S/Fh
STF2603		19482	+7016	4.0	6.9	20.6	3.16	2017.686	4	CTT	S/Fh+N/F
STF2611		19588	+4721	8.5	8.5	205.8	5.12	2017.693	4	CTT	S/Fh+N/F
S738	AB	20106	+3338	7.8	8.4	106.0	42.43	2017.723	2	CTT	S/Fh
STT541	BC	20106	+3338	8.4	9.7	182.0	1.77	2017.723	2	CTT	S/Fh
STT426		21012	+4609	5.4	9.5	159.1	2.89	2017.792	2	CTT	S/Fh
MLB1096		22029	+6716	8.7	10.0	311.5	18.50	2017.793	3	CTT	S/Fh
STF2844		21518	+6453	7.0	10.0	260.0	11.87	2017.825	3	CTT	S/Fh+N/F
SHJ345	AB	22266	−1645	6.4	6.6	79.5	1.22	2017.763	4	CTT	N/F+L
ES1028		22424	+5414	7.6	10.6	243.3	6.03	2017.820	4	CTT	S/Fh+N/F
STF2950	AB	22514	+6142	6.0	7.1	271.2	1.18	2017.839	4	CTT	S/Fh+N/F+L
STF2950	AC	22514	+6142	6.0	11.1	354.0	39.21	2017.821	2	CTT	S/Fh+N/F
STF3049	AB	23590	+5545	5.0	7.2	326.9	3.06	2017.830	1	CTT	N/L

Table 2 – Notes

Pair	ADS	Notes
STF61	683	Nearly fixed since W. Struve (1832).
STF186	1538	Orbital pair, direct relative motion. Second revolution since W. Struve (1831).
STF202AB	1615	Long period orbital pair. Retrograde relative motion: 73° in 186 yrs.
STF412AB	2616	7 Tau. Orbital pair: retrograde relative motion: 277° in 187 yrs.
STF550AB	3274	1 Cam. Nearly fixed since W. Struve (1830). Measurement in half distance configuration.
BU1008	4841	η Gem. Slow retrograde relative motion: 46° in 135 yrs. Getting slightly wider: $+0''.9$. Primary: yellow-gold, secondary: blue. Difficult measurement due to magnitude contrast.
STF982AB	5559	38 Gem. Long period orbital pair. Retrograde relative motion: 33° in 188 yrs.
STF1110AB	6175	Long period orbital pair. Retrograde relative motion: 211° in 191 yrs.
STF1110AC	6175	C orbiting extremely slowly around AB. Barycenter of AB determined using

		mass-luminosity relation for O-C residuals.
STF1110BC	6175	Third side of ABC triangle. Using the measurements of this series: (sin A) / BC = 0.013 ; (sin B) / AC = 0.013 ; (sin C) / AB = 0.016.
STF1126AB	6263	Slow direct relative motion: 43° in 188 yrs. Getting closer: $-0''.6$.
STF1224A-BC	6811	Slow retrograde relative motion: 7° in 234 yrs. Getting wider: $+1''.6$.
STF1291AB	7071	Very slow retrograde relative motion: 24° in 188 yrs. Separation without any noticeable change.
STF1289	7075	Nearly fixed since W. Struve (1830).
BU408	7106	Nearly fixed since Burnham (1877).
STF1321AB	7251	Long period orbital pair. Direct relative motion: 53° in 196 yrs.
STT199AB	7303	Slow direct relative motion: 23° in 170 yrs. Separation without any noticeable change. High magnitude contrast. Unobservable pair with the 205 mm Newtonian. At the limit with the 279 mm Schmidt-Cassegrain telescope
STF1338AB	7307	Orbital pair. Direct relative motion: 190° in 188 yrs.
STT229	7929	Orbital pair. Retrograde relative motion: 92° in 171 yrs. Observed at dusk, right at the zenith. Just split with a gap using the 279 mm Schmidt-Cassegrain.
STF1492	7988	Nearly fixed since W. Struve (1831).
STTA108AB		BD+36° 2162/64. Optical pair. The observed increase in separation ($+33''$ in 141 yrs) mainly due to proper motion of A. The measurement mentioned for BD in WDS 2017 Neglected List (68° & $152''.9$ in 1984) is for AB not for BD which is much more distant. From PPM positions for B (PPM 75738) and D (PPM 75758), computed angle and distance for 2017.0 are 88°.5 and $2102''$.
STF1523AB	8119	Orbital pair. Retrograde relative motion. Over 3 complete revolutions since W. Struve (1826).
STF1543AB	8175	Very slow retrograde relative motion: 17° in 186 yrs. Separation without any noticeable change.
STT235AB	8197	Orbital pair. Direct relative motion. Third revolution since O. Struve (1844). Important magnitude contrast. Nearly split with gap using the 279 mm Schmidt−Cassegrain.
STF1573	8313	No noticeable motion since W. Struve (1832).
STF1579AB-C	8347	Very slow direct relative motion: 4° in 185 yrs. Possibly getting wider.
STF1579AB-D	8347	Getting slightly wider: $+3''.6$ since W. Herschel (1782).
STF1645	8561	Very slow retrograde relative motion: 5° or so in 185 yrs. Possibly getting closer: $-0''.6$.
STT257	8714	Nearly fixed since O. Struve (1846)
BU799AB	8772	Slow direct relative motion: 27° in 136 yrs. Getting wider: $+0''.8$.
STF1768AB	8974	Orbital pair. Retrograde relative motion: 340° in 186 yrs.
BU802	9030	No noticeable change since Bunrham (1881). Possibly getting slightly wider. Difficult measurement
STT274	9112	Optical pair. Apparent retrograde motion: 18° in 172 yrs. Getting closer: $-2''.2$. Starting from 1845.67 O. Struve's measurement (71°.2; $14''.80$), the effect of proper motions mentioned in WDS Catalogue would give for 2017.427: 53°.5 and $12''.88$.
STF1835A-BC	9247	Very slow direct relative motion: 9° in 185 yrs. Separation without any noticeable change.
STF1864AB	9338	Very long period orbital pair. Retrograde relative motion: 13° in 187 yrs. Getting closer: $-0''.3$. No orbital elements available so far.
STF1864AC	9338	Optical pair. Observed motion: 3° direct in 136 yrs. Separation: $+2''$.
STF1888AB	9413	Orbital pair. Second revolution since W. Struve.
STF1909	9494	Orbital pair. Direct relative motion: 203° in 185 yrs. Getting closer. Nearly one magnitude difference between components. Pair just split with the 279 mm Schmidt−Cassegrain. '8' shaped diffraction figure using the 205 mm Newtonian.
STF1919	9535	Nearly fixed since W. Struve (1832). Labelled STF1919AB in CHARA 4th Interferometric Catalogue.
STF1938Ba-Bb	9626	Long period orbital pair. Retrograde relative motion: 352° since 1782.
STF1965	9737	Very slow direct relative motion: 4° in 188 yrs. Getting slightly wider.
BU627A-BC	10227	Very long period orbital pair. Direct relative motion: 94° in 139 yrs.
STF2118AB	10279	Orbital pair. Retrograde relative motion: 178° in 185 yrs.
STF2140AB	10418	α Her. Very long period orbital pair. Retrograde relative motion: 13° in 188 yrs.
STF2180	10597	Nearly fixed since W. Struve (1831).
STF2310	11273	Nearly fixed since W. Struve (1830).

STT359	11479	Orbital pair. Retrograde relative motion: 347° in 168 yrs.
HJ2850	11934	No noticeable change since 1876.
STF2534	12478	Nearly fixed since W. Struve (1830).
STF2603	13007	Slow direct relative motion: 29° in 185 yrs.
STF2611	13209	Nearly fixed since W. Struve (1831).
S738AB	13463	Very slow retrograde motion: 5° in 193 yrs.
STT541BC	13463	Very slow retrograde motion: 9° in 177 yrs.
STT426	14549	Very slow retrograde relative motion: 6° in 169 yrs. Separation without any change.
MLB1096		BD+66° 1470. Fixed since 1894.
STF2844	15408	Nearly fixed since 1895.
SHJ345	15934	Long period orbital pair. Direct relative motion: 137° in 194 yrs. Near periastron. Culminating only 25° above the horizon. Due to atmospheric dispersion, stars looking at times elongated in North−South direction and showing small spectra.
ES1028	16203	Nearly fixed since Espin (1910).
STF2950AB	16317	Long period orbital pair. Retrograde relative motion: 47° in 185 yrs. Getting closer: −0″.9.
STF2950AC	16317	Nearly fixed since 1910.
STF3049AB	17140	Nearly fixed since W. Struve (1833).

Table 3 - Residuals

Pair	ADS	Residual(O−C) PA(°)	Sep (″)	Orbit	Period (yrs)	Date	Grade
STF186	1538	−4.7	+0.08	Mourao	162	1977	2
		+0.4	0.00	USNO	166	2007	2
STF202AB	1615	+3.6	+0.13	Scardia	933	1983	4
		+0.9	+0.05	Scardia	3267	2015	4
STF412AB	2616	+3.3	0.00	Scardia	522	2002	3
STF982AB	5559	+0.1	−0.08	Mason	1898	2014	4
STF1110AB	6175	−0.4	−0.23	Docobo	460	2014	3
STF1110AC	6175	−2.0	−0.12	Kiyaeva	18700	2015	5
		−5.3	+0.67	″	13500	″	″
		−4.4	+1.16	″	12800	″	″
STF1321AB	7251	−0.6	+0.46	Chang	975	1972	4
STF1338AB	7307	−5.2	+0.10	Scardia	303	2002	3
STT229	7929	+0.4	+0.02	Alzner	320	1998	4
STF1523AB	8119	−0.1	−0.01	Mason	60	1995	1
STT235AB	8197	+1.9	0.00	Söderhjelm	73	1999	2
STF1768AB	8974	+1.0	−0.01	Söderhjelm	228	2000	3
STF1888AB	9413	+0.8	+0.17	Söderhjelm	152	1999	2
STF1909	9494	−0.4	0.00	Zirm	210	2012	2
STF1938Ba-Bb	9626	−0.1	+0.03	Kiyaeva	265	2014	2
BU627A-BC	10227	+2.9	−0.04	Rica Romero	1977	2012	5
STF2118AB	10279	−0.4	−0.14	Scardia	422	2002	3
STF2140AB	10418	+1.6	+0.10	Baize	3600	1978	4
STT359	11479	+2.4	+0.01	Scardia	219	2000	3
SHJ345AB	15934	+7.0	−0.08	Hale	3500	1994	4
STF2950AB	16317	−1.9	+0.04	Zirm	804	2015	4

Figure 1: Home-made filar micrometer attached to a 279-mm (11-inch) Schmidt-Cassegrain Telescope (S/Fh in table 1).

References

1). Courtot, J.-F., 2017, *Webb Society Deep Sky Observer*, **177**, 16.
2). Courtot, J.-F., 2015, *Webb Society Double Star Circulars*, **23**, 6.
3). Courtot, J.-F., 2016, *Webb Society Double Star Circulars*, **24**, 6-7.
4). Courtot, J.-F., 2017, *Webb Society Double Star Circulars*, **25**, 16.

Acknowledgements

Sincere thanks to Bob Argyle for arranging and editing this Circular and to our colleagues at the US Naval Observatory for maintaining the Washington Double Star Catalogue.

AN IMPROVED TECHNIQUE FOR MEASURING THE SEPARATION OF CLOSE BINARY STARS WITH A FILAR MICROMETER

Grant L. Morris, Greeley, Colorado, USA

E-mail: glmorri@aol.com

Abstract

Seeing induced image wander makes filar micrometer measurement of binary star separation difficult. An adaptation of the classic psychophysics Method of Adjustment is tested to address this difficulty.

Introduction

Measuring double star position angles and separation with a bifilar micrometer requires superimposing the micrometer wires on the stars' images When attempting to bisect star images with the wires, 'seeing' induced image wander causes difficulty. As Robert G. Aitken observed "...star images are never perfectly defined and never perfectly steady. The observer must place his micrometer threads upon the centers of imperfect star images which are always more or less in motion"[1]. Superimposing the wires of a bifilar micrometer upon the seeing discs involves the pursuit of a moving target.

Image wandering is caused by the presence and movement of patches or cells in the atmosphere that differ in density and refraction. These cells move over time and produce image wander in small telescopes, and blurring in larger telescopes. The size and movement of these cells are the main cause of astronomical seeing. R_o is the size of a typical 'lump' of uniform air within the turbulent atmosphere (an 'isoplanatic cell'). R_o ranges from a few centimeters to more than a meter. At professional observatories, seeing is said to be excellent when R_o is greater than 15 cm, average when around 10 cm, and poor when it falls below 8 cm[2].

When the aperture of a telescope is larger than the size of the cells, the different refractive index of each cell results in multiple images of a star ('speckles'). In other words, the different refractive 'tilt' of these cells creates multiple confused images when photographed. Longer duration viewing or imaging produces the image wander and blurring that we attribute to poor seeing.

For a smaller telescope, what stellar images will look like depends entirely on the seeing cell size compared to the telescope aperture. If the aperture of a telescope is smaller than the size of the cells, speckles are not apparent and blurring is reduced. However, image wander remains a problem. This is because the cells are not stable, but move across the field of view with atmospheric turbulence, wind, and convection. It will be common to see a sharp Airy disc, but the diffraction-limited disc will wander around as different cells imposing different wavefront 'tilts' pass over the aperture. The wandering is often $2''$, and can be several oscillations per second.

Much effort can be spent trying to achieve a satisfactory superimposition of the micrometer wires upon the wandering image of close double stars. It is just these close pairs that are of the most interest, because they are likely to have shorter orbital periods. Image wander is especially challenging when measuring faint pairs with significant differences in brightness. This effort may well end when the limit of the observer's tolerance of frustration has been reached rather than when accurate setting of the bifilar wires has been achieved.

The conventional method for dealing with the errors caused by less-than-perfect seeing is to make multiple observations of separation and position angle during a session and over multiple nights, and then average them. However, my personal experience is that a single measurement of a double star (of a known position angle and separation) made during a rare moment of perfect seeing is more accurate than averages of multiple observations made when seeing is judged to be only very good. 'Perfect' is when there is no image wander or scintillation and a steady, unbroken diffraction ring. Similar reports can be found in the literature[3]. These moments of perfect seeing are far too rare to be the basis of any practical observation program. I mention them only to illustrate the impact of image wander on double star measurement.

There is another problem with micrometer wire superimposition when dealing with very close doubles. As W. H. van den Bos, in 'Some Hints for Double-star Observers...' said: *Dawes pointed out, long ago, that when a thread is brought over a star image, this appears to swell out in a direction perpendicular to the thread and that this may lead to a severe over-measurement of the separation of a close pair. More reliable results are obtained if the observer first tries to fix the distance between the image centers in his memory, then brings the wires over the pair and attempts to make the separation of their centers conform to that of the stars. If the objection is raised that this procedure should be called a measured estimate rather than a measurement, my reply would be that any measurement—bisection included is, in essence, an estimate depending on some judgement on the part of the observer, that the proof of the pudding is in the eating thereof, and that, in my experience, this procedure gives more reliable results than any other I can think of*[4].

Is the bisection of star images with the wires the best way to measure close binaries with a micrometer? The reality is that direct superimposition of the wires upon wandering star images of close binaries is often illusory. In those instances, what the observer is actually doing is similar to a classic psychophysics procedure known as the Method of Adjustment. This was described in the mid 1800s by Gustav Fechner[5]. While most often used for determining thresholds of sensation, the method of adjustment can be used for matching an above-threshold stimulus to another for determining the point of subjective equality or the PSE. The PSE is the setting of one stimulus to another so that the observer experiences them as identical. For example, in vision research, the experimenter might present a light of a known intensity and wavelength (colour). A participant would be asked to adjust another light of a different wavelength to be equally bright as the first one. While this procedure would tell us something about the effects of intensity and wavelength upon perceived brightness, it would also demonstrate the accuracy and reliability with which equivalence judgements can be made.

Measuring separation with a micrometer is often more subjective than the method's apparent precision would lead us to believe. In setting the micrometer wires on close binaries, actual superimposition is often fleeting. The observer must often be satisfied with a best estimate–a point of subjective equality.

Rather than attempting superimposition of wires on discs, can an explicit use of the method of adjustment result in more accurate measures of separation in very close doubles? A 'match-to-sample' technique with the bifilar micrometer would have the observer first positioning the parallel wires off to one side of the binary star image. The observer would then adjust the separation of the wires to match the apparent separation of the binary pair. The frustration of attempting to align the wires on a wandering binary image would be avoided.

Paul Baize used a technique with close doubles that was similar to this. While using a 12-inch telescope, he said that image wander in doubles less than $0''.7$ separation made wire superimposition difficult. Instead, he "...replaces the usual bisection of the stars by an estimation of their separation made by placing the wires so that their distance apart appears equal to that of the stars" [6]. Unfortunately, his use of this technique was not explicitly linked to any data, so its accuracy cannot be evaluated.

Let's see if we can design a study to test this prediction: with very close double stars, a match-to-sample (MTS) technique will produce more accurate measurement of separation than conventional filar superimposition.

Method

I was the only observer. Consequently, this is not a 'blind' experiment–I was, obviously, aware of the predictions for the observing techniques. I made conscientious effort for the best possible measurement, regardless of the technique being used. Nevertheless, this is a criticism of this demonstration.

All observations were made with an 8-inch SCT. A microscope micrometer (Tiyoda No4328) with a position angle scale had been adapted for field illumination by inserting a modified off-axis guider in the optical train. The modification consisted of reversing the off-axis prism so that the light from an adjustable red LED illuminator would be reflected into the micrometer. The micrometer eyepiece in combination with a 5X Barlow gave a power of x400. The screw constant is $11''.43$ per revolution as determined by transit timing. This is an equivalent reading accuracy of $\pm 0''.028$ using 0.2 division interpolations of the micrometer scale. The estimated width of the etched lines in the micrometer is $0''.15$

Figure 1: The Tiyoda filar micrometer (left) and Celestron Ultima 8-inch PEC SCT used for this demonstration (right). Attached to telescope are a Crayford focuser, the modified off-axis guider used for red field illumination, diagonal, 5X Barlow and micrometer.

The binaries selected are listed in the table above in order of decreasing separation. The match-to-sample technique was predicted to be more accurate for very close binaries. Therefore, some of the selected binaries are closer than the resolution limits typically suggested for an 8-inch f10 SCT (Dawes: $0''.58$; Rayleigh: $0''.69$).

The purpose of this project was to demonstrate the difference between the measuring techniques under identical circumstances of seeing, operator fatigue, etc. For these reasons, observations were sometimes made under conditions, and for separations, that would not be acceptable when accuracy of separation measurement was the primary goal.

The listed separations of the selected binaries were measured during at least one complete observing run. A observing run on a binary pair consisted of four double-distance measurements with both techniques (MTS and superimposition). When possible, runs were repeated for additional nights for a maximum of three nights. My observing location is surrounded by nearby trees, and has a opening near zenith which is little more than one hour of right ascension in size. Also, at my location near the front range of the Rocky Mountains of Colorado at 4700 feet, tolerable seeing is often restricted to a brief period after twilight. Consequently, if clouds or other factors prevent observing for several nights, a binary moves beyond view.

Pair	J2000	Va	Vb	WDS Sep(″)	MTS Sep(″)	Sup Sep(″)	Epoch	N Obs
STF1523	11182+3132	4.33	4.80	1.93	1.92	1.93	2017.36	3
STF2822	21441+2845	4.75	6.18	1.51	1.53	1.57	2017.67	1
STF2583	19487+1149	6.34	6.75	1.5	1.39	1.37	2017.65	2
STF73	00550+2338	6.12	6.54	1.13	1.21	1.26	2016.86	3
STT288	14534+1542	6.89	7.55	0.98	0.92	1.12	2017.45	1
STT395	20020+2456	5.83	6.19	0.85	0.87	1.04	2017.67	2
STT359	18355+2336	6.35	6.62	0.75	0.79	0.97	2017.66	2
STF186	01559+0151	6.79	6.84	0.71	0.85	0.91	2016.92	1
STF1555	11363+2747	6.41	6.78	0.68	0.76	0.86	2017.36	1
STF1937	15232+3017	5.64	5.95	0.49	0.7	0.82	2017.45	2

Table 1: Binary pairs used in decreasing order of separation. WDS is the separation found in the Washington Double Star catalog (when available, orbital elements were used to calculate separation for the mean date of observations[7]). MTS is the separation observed using the Match-to-Sample technique; Sup Sep is the separation found with conventional filar Superimposition.

The position angle of the pair was determined. Then, if using the Superimposition double-distance technique, "…the fixed wire of the micrometer is placed on the primary star and the movable wire on the companion. The reading of the movable wire is noted. The telescope and micrometer screw are then moved until the fixed wire is placed on the companion and the movable wire placed on the primary star. The difference between the two positions of the screw is twice the separation of the pair"[8]

With the Match-to-Sample technique, the bifilar wires would be placed to one side of the binary stars. Using the above procedure of reversing the wires, a double-distance separation measure was made. I always placed the wires just to the left of the binary pair, at a distance approximately equal to the pairs perceived separation, so that at the end of measurement, the stars and wires were spaced roughly so: $\|\|\| * *$. The stars would be placed just above the horizontal or PA wire.

During an observing run, four double-distance measures would be made first with one technique, and then the other. The order of technique would be alternated, so that approximately half of the pairs were observed first with the MTS technique, and other pairs first observed with Superimposition. If there was more than one observing session for a given pair, the same order was always used.

I also alternated the direction of adjustment of the wire pair for each double-distance measure. This was because I had noticed a tendency for 'closing' measurements to be larger than 'expanding' ones. For each double-distance measure, starting with the wires together and then opening them to match the stars was alternated with starting with the wires well separated, and then closing upon the final separation adjustment.

Results

The average errors of measurement comparing the match-to-sample and the filar superimposition techniques is shown in the figure below. For binaries with a WDS separation under 1″ , there is a clear trend for both techniques to have larger measurement error as separation becomes less; however, in every instance, the match-to-sample technique shows the smaller error of measurement. For the binaries with a separation of around 1″ or greater; the measurement errors are less systematic and distributed fairly evenly around zero error.

My experience was that superimposition became increasingly difficult as the separation became smaller — the very inspiration for this project. The match-to-sample technique not only resulted in smaller error of measurement, it was less frustrating and quicker. As was reported above by binary star astronomers, it is difficult to superimpose the wires—the binary pair will be oscillating back and forth over the stationary wires. Most often when attempting superimposition, I would actually be trying to see if the wires were offset the same amount from each star as the pair moved back and forth—in effect, something in between a superimposition and a match-to-sample.

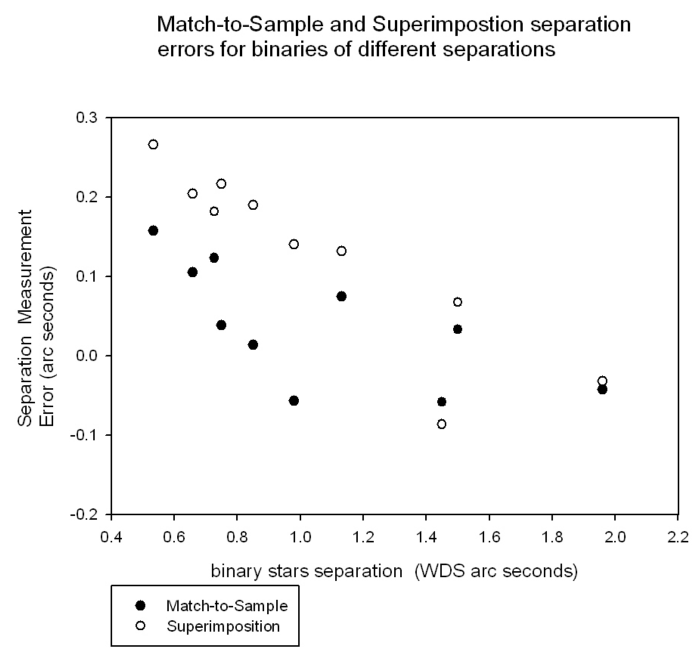

Figure 2: Match-to-sample and superposition separation error for binaries of different separations

With this telescope and micrometer setup, it looks as though 1″ of separation is the point below which the match-to-sample technique works better. Between 1″ and 2″ , there is little difference in accuracy between the techniques; however, I still found the match-to-sample technique quicker and easier. I did try this technique on a binary larger than 2″ separation, and found Superimposition to be more accurate. At that point, the gap between the stars became so large that I found it difficult to match it with the spacing of the filar wires.

In the present study, field rather than wire illumination was used. Field versus wire illumination with filar superimposition has been discussed elsewhere[9]. Field illumination competes with the stars' brightness, and limits the lower magnitude of binaries that can be measured. On the other hand, superimposition of illuminated wires obscures the stars at the point of measurement. Using an illuminated wire micrometer with the match to sample technique with the stars offset from the wires would seem to address these problems, and would permit measurement of fainter and more unequal pairs.

There have been numerous attempts at improving double star measurement with various devices such as comparison image and birefringement micrometers[10]. Despite their promise, these have not found wide use. This may be because these devices are difficult and expensive to make, and, for the most part, have not been available commercially. Microscope bifilar micrometers are widely available and inexpensive. These can be adapted for telescopic use. Occasionally, a bifilar micrometer designed for a telescope with a position angle scale shows up on the used market. The proposed match-to-sample technique is similar in method and advantage to that for comparison and birefringement devices, but uses a conventional filar micrometer.

I cannot discount the possibility that my biases and expectations may have affected these results. Therefore, I hope others will give the match-to-sample technique a try, and report their experience.

References

1). Aitken, R. G., 1938, On Observing Double Stars, ASP, Leaflet No. 117, p137.
2). `https://en.m.wikipedia.org/wiki/Astronomical_seeing`
3). Davidson, C. R. & Symms, L.S.T., 1938, A comparison image micrometer, MNRAS **98**, 185, note accompanying observation of ADS 2616.
4). van den Bos, W. H., Some Hints for Double-Star Observers and Orbit Computers, PASP **70**, No. 413, p.160
5). `http://peace.saumag.edu/faculty/kardas/courses/HP/Lectures/fechner.html`
6). Davidson, C. R. & Symms, L.S.T., 1938, A comparison image micrometer, MNRAS **98**, 181
7). Binary star position angle and separation calculator:
`https://www.nebulousresearch.org/codes/binaries/`
8). Argyle, R. W. (ed.), 2012, *Observing and Measuring Visual Double Stars*, Springer, p.174.
9). Gill, D., 1891, Article about micrometers in the Encyclopedia Britannica, 9th ed., Vol. XVI, p.258:

{\tt https://books.google.com/books?id=edtEAQAAMAAJ\&pg=PA252\&lpg=PA252\&dq=telescope+filar+micrometer+illumination\&source=bl\&ots=gJviytOmKq\&sig=267D5sny_QCtPA2jcGCteFI-cGo\&hl=en\&sa=X\&ei=mmlOVYC3KpTVoATJv4CIBg\&ved=0CCUQ6AEwAw\#v=onepage\&q=telescope\%20filar\%20micrometer\%20illumination\&f=true}

10). Worley, Charles. Observational techniques and results for visual double stars. USNO:

{\tt http://articles.adsabs.harvard.edu/cgi-bin/nph-iarticle_query?1983LowOB...9....1W\&data_type=PDF_HIGH\&\amp;whole_paper=YES\&type=PRINTER\&filetype=.pdf}

ASTRONOMICAL ASSOCIATION OF QUEENSLAND 2016 PROGRAMME: MEASUREMENT OF NINE NEGLECTED SOUTHERN MULTIPLE STARS

Graeme Jenkinson, Astronomical Association of Queensland

E-mail: bluestars@iprimus.com.au

Summary

This paper presents the results of an early 2016 programme of photographic measurements of nine southern multiple stars. Two of these targets consisted of both B and C components. These are the first completed results obtained using an Atik 460EX mono CCD camera purchased in late 2015 with a grant from the AAQ Edward Corbould Research Fund grant. This imager is being used in conjunction with an equatorially mounted 400-mm f4.5 reflector. Image processing was carried out using Losse's REDUC software.

The mean 95% confidence intervals for the new measures were ± 0°.949 in PA and ± 0″.176 in separation. The results were as follows:

System	Con	Last listed measure			New measure			Comment
		PA(°)	Sep.(″)	Epoch	PA(°)	Sep(″)	Epoch*	
B1673AB	Car	165.0	16.4	1931	157.17	16.85	2016.123	Decrease in PA of 8°
B1673AC	Car	6.0	26.0	1932	6.86	25.85	2016.123	Possible slight movement
BRT807	Cen	159.0	2.8	1899	195.07	10.21	2016.189	Large change since 1899
HDO220	Cen	210.0	6.3	1947	208.35	5.87	2016.209	Minor probable movement
SEE165AB	Cen	175.0	3.5	1969	179.47	3.56	2016.240	4° change in PA
SEE165AC	Cen	233.0	21.4	1999	234.49	20.69	2016.240	Possible slight movement
RST3816AB	Vir	82.0	6.9	1943	83.53	6.76	2016.238	1°.5 increase in PA
B1223	Cen	153.0	4.8	1942	152.30	4.76	2016.242	Little change since 1942
B255	Hya	174.0	4.1	1960	149.05	3.65	2016.328	25° increase in PA
DON1109	Hya	318.0	6.3	1928	337.92	3.79	2016.318	Sep. decreased by 2″.5
I 1573	Cen	350.0	10.0	1927	359.31	9.72	2016.311	9° movement in PA

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

Introduction

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

Method

Once obtained with the equipment described above, the images were analysed using the astrometric double star program REDUC[1]. 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[2]. Some recent work on the errors inherent in the method is described in Napier-Munn and Jenkinson[3]. 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 below 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 catalogued value ($P < 0.05$ is considered as evidence of change).

Measurements

B1673AB Carina RA. 10 17.1 DEC. -61 20 Last Measure 1931 MAG. 3.40 & 12.6 PA. 165°.0 SEP. 16″.4

COMMENTS Definite movement in PA.

Figure 1: B 1673 in Carina

Date	No. images	PA(°)	Sep(″)
08 February 2016	10	158.45	17.098
09 February 2016	10	158.6	16.988
11 February 2016	10	158.25	16.492
12 February 2016	10	158.35	16.969
15 February 2016	10	155.39	16.634
26 February 2016	10	155.1	17.016
29 February 2016	10	156.06	16.763
Mean (J2016.123)		157.171	16.851
Standard deviation		1.577	0.225
95% CI ±		1.459	0.208
P(t) movement		0.00	0.00

Table 1: Individual measures of B 1673 AB

B1673AC Carina RA. 10 17.1 DEC. -61 20 Last Measure 1932 MAG. 3.4 & 12.7 PA. 6° SEP. 26″.0

COMMENTS Possible slight change in PA since the only previous measurement.

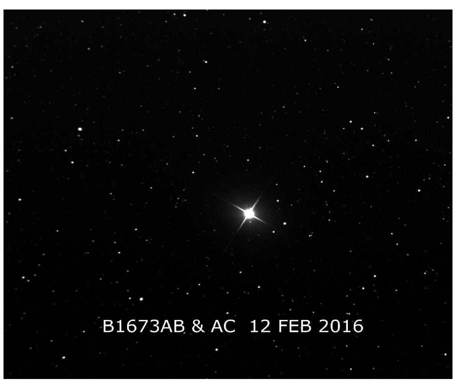

Figure 2: B 1673 AC in Carina

Date	No. images	PA(°)	Sep(″)
08 February 2016	10	6.9	25.801
09 February 2016	10	6.6	25.8
11 February 2016	10	6.63	25.795
12 February 2016	10	6.5	25.901
15 February 2016	10	7.02	25.926
26 February 2016	10	7.49	25.826
29 February 2016	10	6.85	25.917
Mean(J2016.123)		6.856	25.852
Standard deviation	0.335	0.060	
95% CI ±	0.310	0.055	
P(t) movement	0.001	0.001	

Table 2: Individual measures of B 1673 AC

BRT807 Centaurus RA. 12 16.5 DEC. -42 11 Last Measure 1899 MAG. 10.73 & 10.7 PA. 159°. SEP. 2″.8

COMMENTS Significant movement since the only previous measurement in 1899.

Figure 3: BRT 807 in Centaurus

Date	No. images	PA(°)	Sep(″)
03 March 2016	10	194.82	10.21
05 March 2016	10	195.19	10.217
08 March 2016	10	195.07	10.21
09 March 2016	10	195.31	10.23
14 March 2016	10	195.25	10.225
19 March 2016	10	194.86	10.197
24 March 2016	10	194.96	10.212
Mean(J2016.189)		195.066	10.214
Standard deviation		0.193	0.011
95% CI ±		0.178	0.010
P(t) movement		0.000	0.000

Table 3: Individual measures of BRT 807

HDO220 Centaurus RA. 12 52.4 DEC. -53 50 Last Measure 1947 MAG. 6.39 & 11.7 PA. 210° SEP. 6″.3

COMMENTS Only minor possible movement in the last seventy years. Poor quality images from 09 March 2016 deleted from reduction calculations.

Figure 4: HDO220 in Centaurus

Date	No. images	PA°	Sep(″)
05 March 2016	10	208.43	5.788
14 March 2016	10	209.82	6.062
19 March 2016	10	205.66	5.669
24 March 2016	10	207.28	5.99
25 March 2016	10	209.22	5.904
27 March 2016	10	209.67	5.905
Mean(J2016.209)		208.347	5.886
Standard deviation		1.615	.141
95% CI ±		1.695	.148
P(t) movement		0.054	.001

Table 4: Individual easures of HDO 220

SEE165AB Centaurus RA. 12 53.2 DEC. -39 23 Last Measure 1969 MAG. 7.03 & 12.5 PA. 175° SEP. 3″.5

COMMENTS Increase in PA of approx. 4° since the first measurement in 1900. Minimal change in separation over the same period.

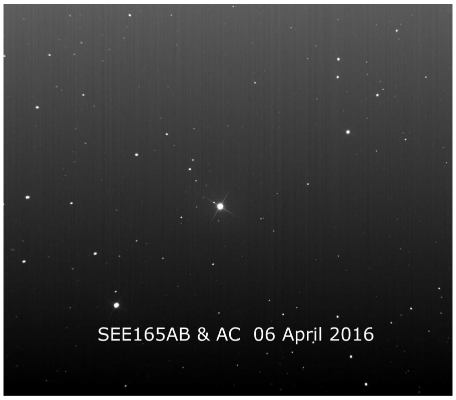

Figure 5: SEE 165 AB in Centaurus

Date	No. images	PA°	Sep(″)
19 March 2016	10	176.93	3.848
25 March 2016	10	180.62	3.38
30 March 2016	10	179.52	3.532
01 April 2016	10	179.98	3.569
02 April 2016	10	180.94	3.455
05 April 2016	10	179.75	3.525
06 April 2016	10	178.55	3.609
Mean(J2016.240)		179.470	3.560
Standard deviation		1.362	0148
95% CI ±		1.259	0137
P(t) movement		0.000	0326

Table 5: Individual measures of SEE 165 AB

SEE165AC Centaurus RA. 12 53.2 DEC. -39 23 Last Measure 1999 MAG. 7.03 & 14.0 PA. 233° SEP. 21″.4

COMMENTS Some movement evident.

Figure 6: SEE 165 AC in Centaurus

Date	No. images	PA(°)	Sep(″)
19 March 2016	10	233.78	20.875
25 March 2016	10	234.93	20.948
30 March 2016	10	234.74	20.968
01 April 2016	10	234.53	18.989
02 April 2016	10	234.88	21.099
05 April 2016	10	234.21	21.014
06 April 2016	10	234.38	20.943
Mean(J2016.240)		234.493	20.691
Standard deviation		0.409	0.754
95% CI ±		0.378	0.697
P(t) movement		0.000	0.047

Table 6: Individual measures of SEE 165 AC

RST3816AB Virgo RA. 12 56.7 DEC. -11 57 Last Measure 1943 MAG. 7.63 & 14.0 PA. 82° SEP. 6″.9

COMMENTS Possible minor change in PA.

Figure 7: RST 3816 AB in Virgo

Date	No. images	PA(°)	Sep(″)
25 March 2016	10	84.21	6.835
27 March 2016	10	85.08	6.791
30 March 2016	10	82.76	6.683
01 April 2016	10	82.67	6.665
02 April 2016	10	82.5	6.703
05 April 2016	10	85.59	6.81
06 April 2016	10	81.87	6.796
Mean(J2016.238)		83.526	6.755
Standard deviation		1.429	0.069
95% CI ±		1.322	0.064
P(t) movement		0.030	0.001

Table 7: Individual measures of RST 3816 AB

B1223 Centaurus RA. 13 08.6 DEC. -43 55 Last Measure 1942 MAG. 9.69 & 13.2 PA. 153° SEP 4″.8
COMMENTS Two previous measurements, 1928& 1942. The 20° change in PA recorded there has not been evident with the latest measurement.

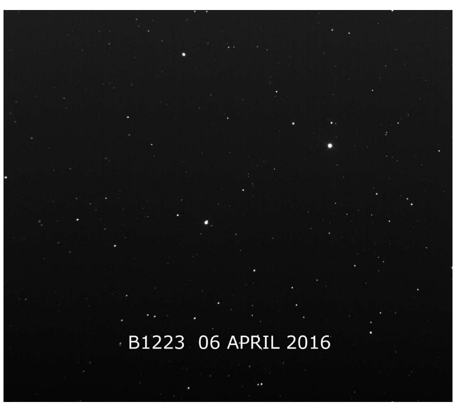

Figure 8: B 1223 in Centaurus

Date	No. images	PA(°)	Sep(″)
27 March 2016	10	152.68	4.759
28 March 2016	10	152.19	4.789
30 March 2016	10	152.51	4.872
01 April 2016	10	151.86	4.819
02 April 2016	10	152.2	4.67
05 April 2016	10	152.28	4.706
06 April 2016	10	152.39	4.742
Mean(J2016.242)		152.301	4.765
Standard deviation		0.262	0.068
95% CI ±		0.243	0.063
P(t) movement		0.000	0.227

Table 8: Individual measures of B 1223

B255 Hydra RA. 13 48.5 DEC. -23 51 Last Measure 1960 MAG. 8.98 & 13.2 PA. 174° SEP 4″.1
COMMENTS Movement in both axes appear consistent with the five previous measurements.

Figure 9: B 255 in Hydra

Date	No. images	PA(°)	Sep(″)
08 April 2016	10	148.91	3.723
13 April 2016	10	149.88	3.616
30 April 2016	10	151.34	3.526
11 May 2016	10	146.52	3.629
13 May 2016	10	147.38	3.545
15 May 2016	10	151.63	3.637
16 May 2016	10	147.66	3.946
Mean(J2016.328)		149.046	3.650
Standard deviation		1.989	0.152
95% CI ±		1.839	0.160
P(t) movement		0.000	0.001

Table 9: Individual measures of B 255

DON1109 Hydra RA. 13 57.4 DEC. -23 21 Last Measure 192 MAG. 9.93 & 14.1 PA. 318° SEP 6″.3

COMMENTS Separation appears to be closing again after the increases recorded in 1920 & 1928.

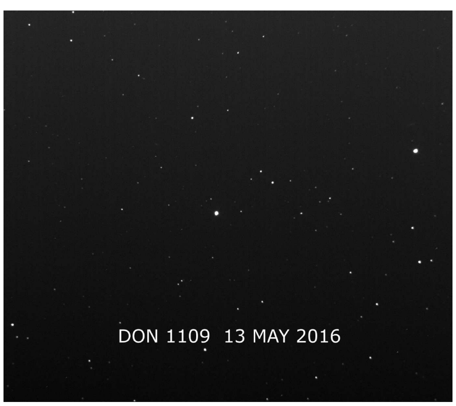

Figure 10: DON 1109 in Hydra

Date	No. images	PA(°)	Sep(″)
08 April 2016	10	338.02	3.494
18 April 2016	10	337.24	3.981
23 April 2016	10	337.85	3.668
24 April 2016	10	340.52	4.109
04 May 2016	10	335.79	3.409
13 May 2016	10	338.73	4.099
16 May 2016	10	337.27	3.764
Mean(J2016.318)		337.91	7 3.789
Standard deviation		1.464	0.283
95% CI ±		1.354	0.262
P(t) movement		0.000	0.000

Table 10: Individual measures of DON 1109

I 1573 Centaurus RA. 14 01.3 DEC. -40 13 Last Measure 1927 MAG. 6.13 & 12.5 PA. 350° SEP 10″.0

COMMENTS Evident movement in PA since the original 1927 measurement. First two nights PA measurements not included for calculation of mean.

Acknowledgements

This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory. The Edward Corbould Research Fund administered by the Astronomical Society of Queensland for granting of funds to upgrade imaging camera and observatory computer to suit.

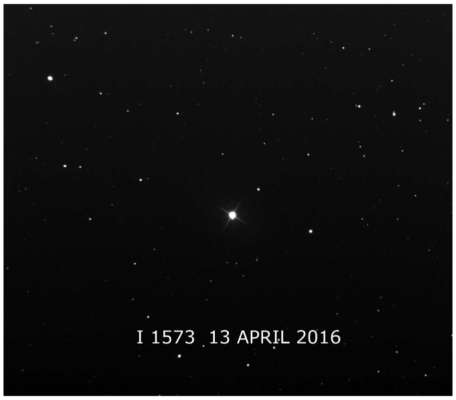

Figure 11: I 1573 in Centaurus

Date	No. images	PA(°)	Sep(″)
08 April 2016	10	1.27	9.836
13 April 2016	10	0.64	9.841
23 April 2016	10	359.84	9.717
24 April 2016	10	359.06	9.826
30 April 2016	10	359.05	9.82
07 May 2016	10	359.4	9.547
11 May 2016	10	359.2	9.471
Mean(J2016.318)		359.31	0 9.723
Standard deviation		0.328	0.153
95% CI ±		0.408	0.142
P(t) movement		0.000	0.003

Table 11: Individual measures of I 1573

References

1). Losse, F. Reduc software, V4.5.1. http://www.astrosurf.com/hfosaf/uk/tdownload.htm
2). Napier-Munn, T.J. and Jenkinson, G., 2009. Measurement of some neglected southern multiple stars in Pavo. *Webb Society Double Star Section Circular* **17**, 6-12.
3). Napier-Munn, T.J. and Jenkinson, G., 2014. Analysis of errors in the measurement of double stars using imaging and Reduc software. *Journal of Double Star Observations* Vol. 10 No.3.
4.) Argyle, R.W., 2012. *Observing and Measuring Visual Double Stars, 2nd edition.* Springer.

MEASUREMENTS OF DOUBLE STARS WITH ROBOTIC TELESCOPES IN 2017

A. Debackère, Sociètè Astronomique de France

e-mail : andre.debackere@free.fr

Abstract

These observations and measurements were made with the LCOGT Global Telescope Network.

Explanation of Table

Col.1	WDS designation (based on 2000 coordinates)
Col.2	Discoverer Number
Col.3	Components
Col.4	Mean date of observation
Col.5	Number of Observations
Col.6	Position Angle
Col.7	Separation (first measure)
Col.8	Magnitude of First Component
Col.9	Magnitude of Second Component
Col.10	Catalog identifier (UCAC4 otherwise GAIA DR1, or USNO-B.1.0 “Not id” when the object does not appear in any of the previous catalogs)
Col.11	Number of nights and Observatory code
Col.12	Notes
Col.13	2000 arcsecond coordinates (GAIA DR1)

Table: Measures

WDS	Disc.	Comp.	Epoch	N	θ	ρ	V_1 V_2	Catalogue ID	Obs	N	Precise coords.
04107+2424	DBR 89	AB	2017.053	1	34.2	4.31	12.5	573-010529	1FTN	2	041040.90+242406.2
		B					14.7	573-010530			041041.08+242409.5
05356-0512	SKF 2277	AB	2017.632	1	145.1	5.49	9.7	424-010324	1FTN		053535.78-051220.
		B					13.0	424-010326			053536.01-051225.3

06435+2254	POU 1958	AB	2017.157	2	140.5	16.60	11.6	565-031665	1Q63		064329.45+225349.8
		B					12.6	565-031667	1K93		064330.21+225336.7
06500+2549	COU 767	AB	2017.223	1	166.9	3.52	9.6	580-033356	1FTN	1	065003.00+254929.3
		B					12.1	Not id			065003.06+254926.2
06559+1829	COU 769	AB	2017.223	1	135.2	2.65	12.4	543-036701	1FTN	1	065551.22+182942.3
		B					13.3	Not id			065551.32+182940.8
07328+2125	COU 479	AB	2017.242	1	262.3	2.03	12.1	588-041850	1FTN	1	073252.28+212503.3
		B					12.5	Not id			073252.19+212503.1
09168+4040	COU 19	AB	2017.180	1	219.0	7.83	11.2	654-050936	1FTN		091645.93+404004.3
		B					11.7	654-0509935	1FTN		091645.49+403958.5
		BC	2017.180	1	346.5	2.39	11.7	654-050935	1FTN	1	091645.49+403958.5
		C					11.9	Not id	1FTN		091645.45+404000.3
09319+2125	DBR 5	AB	2017.179	1	282.7	2.74	12.0	558-048557	1FTN		093155.09+212457.2
		B					12.5	558-048556			093154.90+212457.
09324+2129	DBR 7	A	2017.17		103.	3.7	15.	558-045878	1FTN		093221.96+212836.7
		B					16.0	558-048579			093222.22+212835.7
09569+1946	COU 388	AB	2017.210	2	242.0	1.60	11.8	549-048042	2FTN	1,4	095653.84+194658.5
		B					11.9	Not id			095653.82+194658.3
09570+1946	STF 1399	AB	2017.210	2	175.5	30.41	8.6	549-048048	2FTN	2	095702.21+194544.6
		B					9.0	549-048049			095702.39+194514.2
11383-6322	I 442	AB	,D 2017.152	1	324.0	9.42	7.2	134-057492	1FTS		113820.36−632221.9
		D					11.9	–	1FTS	10	113819.54−632214.2
11386-6322	SKF 939	AB	2017.152	1	90.1	2.27	13.6	134-057606	1FTS		113838.72−632158.2
			B				13.9	134-057609			113839.05−632158.2
11387-6323	SKF 940	AB	2017.152	1	292.2	2.32	12.0	134-057618	1FTS	5	113841.71−632255.1
		B					12.9	Not id			113841.49−632254.4
12095-1151	STF 1604	AB	2017.291	1	88.5	9.03	6.9	391-056520	1FTS	2	120928.54−115125.4
		B					10.0	391-056522			120929.00−115123.8
		AC	2017.291	1	3.6	10.51	6.9	391-056520	1FTS		120928.54−115125.4
		C					8.1	391-056521			120928.93−115116.5
		BC	2017.91	1	321.1	13.60	10.0	391-056522	1FTS		120929.00−115123.8
18024-2302	HN 40	C					8.1				
		E					12.7	Not id			180223.06−230206.0
		CF	2017.643	1	85.5	6.79	9.0	335-131411	1FTS	6	180223.13−230200.0
		F					14.1	Not id			180225.08−230158.0
		CG	2017.643	1	211.7	29.97	9.0	335-131411	1FTS	1,6	180223.13−230200.0
		G					13.1	Not id			180221.99−230225.7
18024-2302	HN 40	AB	2017.643	1	20.3	6.17	8.8	335-131421	1FTS	6	180223.56−230151.1
		B					10.6				180223.71−230145.2
18024-2302	HN 6	AC	2017.643	1	213.0	10.73	8.8	335-131421	1FTS	6	180223.56−230151.1
		C					9.0	335-131411			180223.13−20200.0

		AE	2017.643	1	204.9	16.22	8.8	335-131421	1FTS	6	180223.56−230151.1
		E					12.7	Not id			180223.06−230206.0
		AG	2017.643	1	212.0	40.71	8.8	335-131421	1FTS	6	180223.56−230151.1
		G					13.1	Not id			180221.99−230225.7
18024-2302	HLD 175	AF	2017.643	1	108.4	22.08	8.8	335-131421	1FTS	6	180223.56−230151.1
			F				14.1	Not id			180225.08−230158.0
18083+1318	GWP 2760	AB	2017.241	1	10.9	28.61	10.2	517-070819	1FTS	2	180819.03+131734.4
			B				17.2	1033-0317091			180819.38+131801.9
18186-1348	SNA 87	HJ	2017.552	3	139.1	3.42	7.4	382-101645	2FTN/1FTS	2,7	181836.04−134736.3
			J				12.5	Not id			181836.17−134738.6
18186-1348	SNA 88	AD	2017.552	3	245.7	3.49	6.7	381-104621	2FTN/1FTS	2,7	181836.42−134802.3
			D				14.2	Not Id			181836.21−134803.7
18186-1348	SNA 88	AG	2017.552	3	304.6	6.40	6.7	381-104621	2FTN/1FTS	7	181836.42−134802.3
		G					13.4	Not id			181836.06−134758.7
18187-1347	DCH 29	CD	2017.552	3	184.7	1.08	9.7	382-101698	2FTN/1FTS	7	181840.75−134652.3
		D				10.7		Not id			181840.74−134652.4
18536+3303	HL 9001	AB	2017.550	3	263.1	4.87	15.0	616-065945	3FTN		185334.19+330255.6
			B				15.2	616-065941	3FTN		185333.81+330254.8
		A	2017.550	3	3.8	18.86	15.0	616-065945	3FTN		185334.19+330255.6
			C				15.8	616-065947	3FTN		185334.30+330314.2
18533+3302	POP 192	AB	2017.550	3	42.5	2.51	12.7	616-065892	3FTN		185318.40+330247.2
		B					13.3	209048720289 7504768			185318.53+330249.1
21056+1749	J 797	AB	2017.733	1	213.9	4.08	11.9	540-142303	1FTS	1	210537.30+174946.4
		B					13.5	176425821599 2343552			210537.19+174944.0
21299+1212	MAA 1		2017.631	1	-	-	13.0	511-137207	1FTN	1,3,8	212955.72+121133.7
21497+1216	J 2358	AB	2017.722	1	339.0	4.18	12.5	512-134004	1FTS	1	214938.72+121746.8
			B				12.6	512-134003			214938.61+121750.6
22109+1545	J 1793	AB	2017.729	1	84.6	4.44	13.4	529-145597	1FTN	1	221056.56+154444.5
			B				14.2	529-145598			221056.87+154445.0
22110+1543	J 1794	AB	2017.729	1	229.3	5.13	10.7	529-145603	1FTN		221059.98+154321.7
							11.2	529-145602			221059.71+154318.3
22583+0124	UC 280	AB	2017.719	1	241.8	36.86	10.9	458-127565	1FTN	2	225815.01+012415.7
			B				12.7	457-121044			225812.84+012358.3
22582+0123	HJ 977		2017.719	1	-	-	11.1	- 458-127569	1FTN	1,9	225815.45+012617.3

Observatory code
FTN: Faulkes Telescope North T2m, MPC code F65, Haleakala, Hawaii, LCOGT
FTS: Faulkes Telescope South T2m MPC code E10, Siding Spring, Australia, LCOGT
MPC code Q63: T1m, Siding Spring, Australia, LCOGT
MPC code K93: T1m, Sutherland, South Africa, LCOGT

Notes

1. Neglected couple
2. Physical pair
3. Identification uncertain in the WDS
4. The WDS gives: COU 388 last measure in 1969, 1 observation, $\theta = 69^\circ.10$ and $\rho = 0''.74$ our measures in 2017, $\theta = 242^\circ.035 \pm 1^\circ.050$ and $\rho = 1''.596 \pm 0''.010$
5. The WDS gives: SKF 940 last measure in 2000, $\theta = 100^\circ.00$ and $\rho = 2''.000$ mag. primary 13.30 mag second 13.30 or the images show clearly an error on the position angle (see zoom below) and mag error.

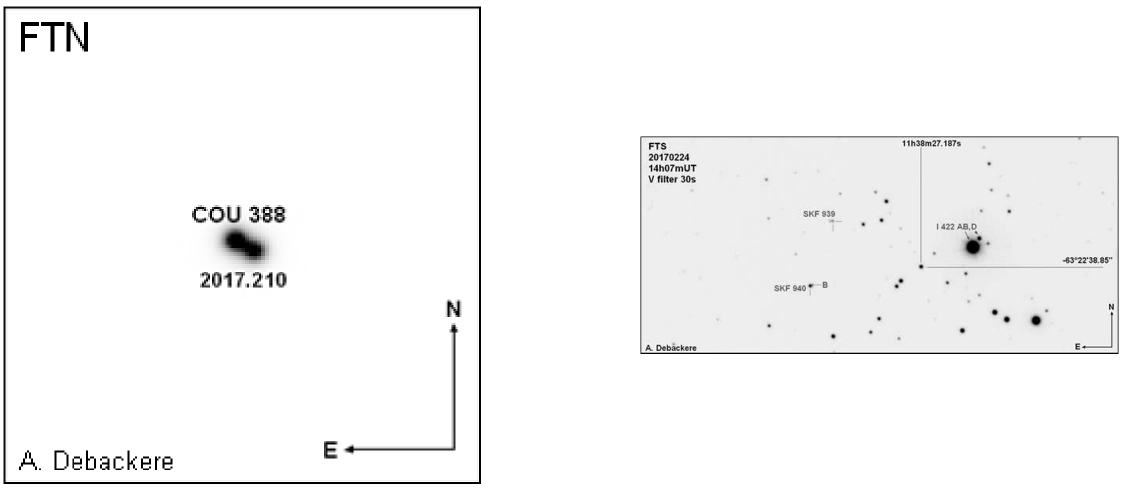

Figure 1:

6. In M20
7. In M16

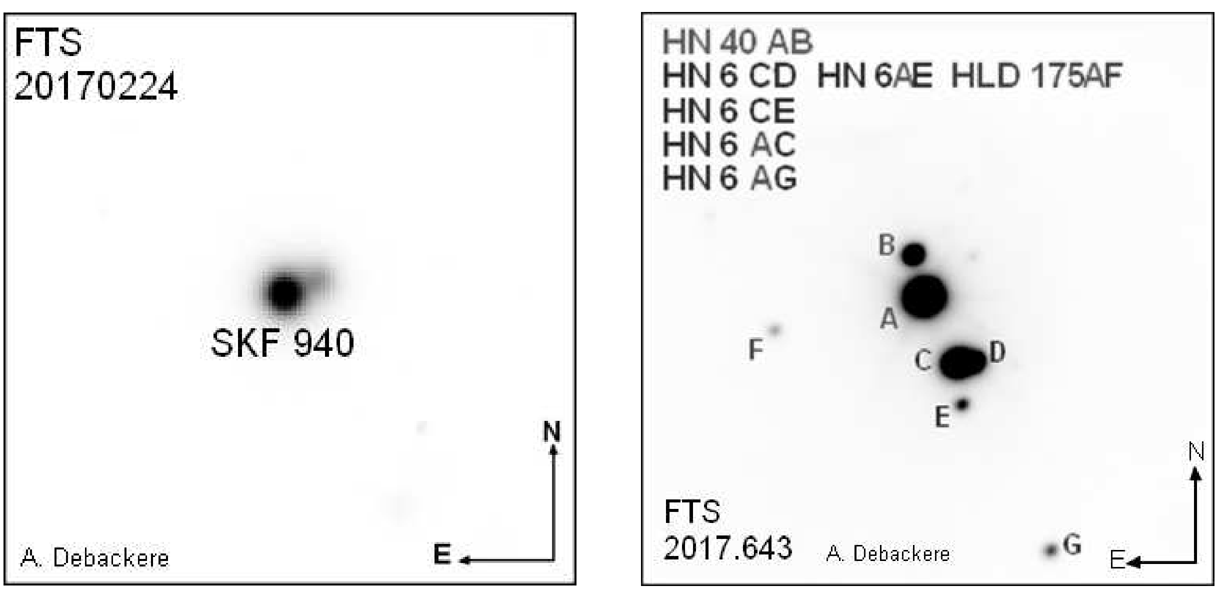

Figure 2:

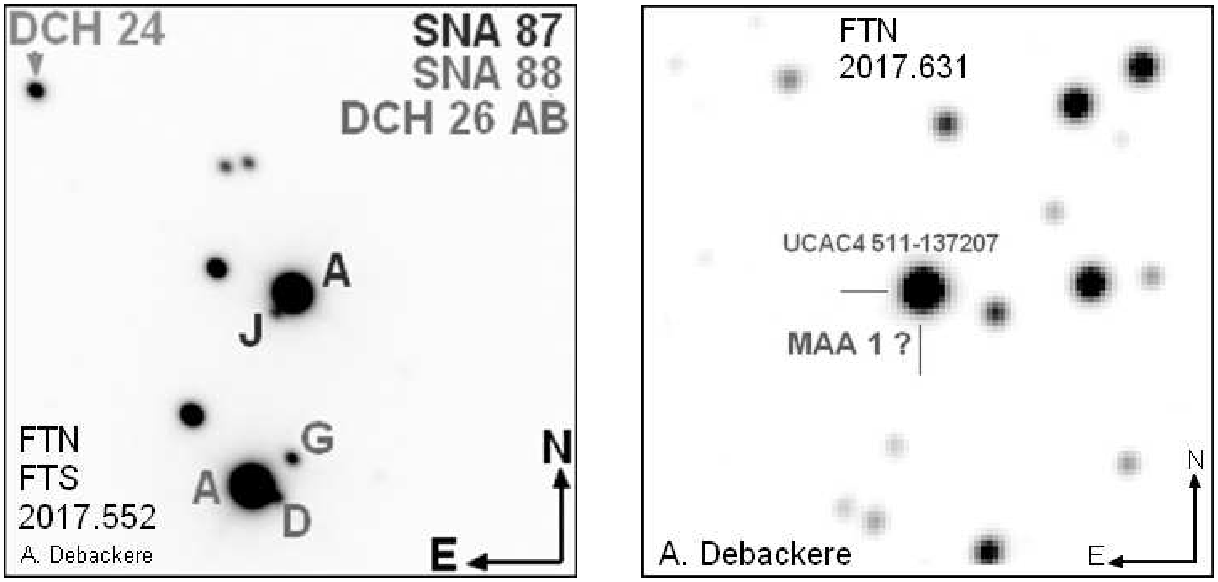

Figure 3: In M16 Image SNA 87_SNA 88_2017.552_FTN_FTS(left). Image MAA1_2017.631_FTN (right)

DCH 24 (neglected), DCH 26 AB and SNA 87 Ha,Hb are too tight to be seen and measured on this image.

Only the component J of the multiple star SN 87 star is seen. The components I and K do not appear on the image or we should see them according to the magnitudes and separations given by the WDS.

Only the components D and G of the multiple star SNA 88 are seen. The components C, E and F do not appear on the image or we should see them according to the magnitudes and separations given by the WDS.

8. In M15, the pair MAA 1 is not separated, the star is seen round, if this star is MAA 1 the separation in 2017 is much less than $1''.0$.

9. The neglected pair HJ 977 is seen round as confirmed by the UCAC4 catalog: "db0=single star". The magnitudes indicated by the WDS catalog do not correspond to those measured on the images of the FTN nor to that indicated by the UCAC4 catalog.

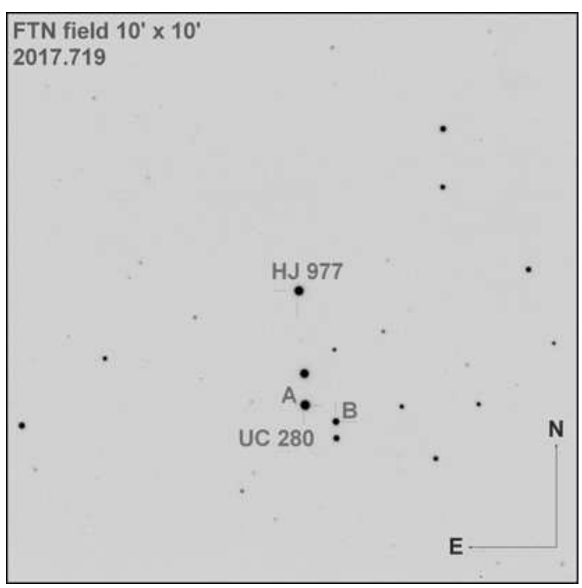

Figure 4: Image HJ 977_UC 280_2017.719_FTN

10. The component D of I 422 is not identified in UCAC4, Gaia-DR1, USNO-B1.0 and Nomad

catalog, but it is HD 101205D in the Henry Draper Catalogue.

Acknowledgments

This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory, and the VizieR catalogue access tool, CDS, Strasbourg, France. The original description of the VizieR service was published in A&AS 143, 23

Special thanks to Herbert Raab, ASTROMETRICA[1] software and Florent Losse, REDUC[2] software

DOUBLE STAR MEASUREMENTS WITH A MEADE 12MM ASTROMETRIC EYEPIECE IN 2017

Neil Webster, Bromley, Kent BR2 0SD

E-mail: nweb124@gmail.com

Introduction

The following measurements were made throughout 2017 using a Meade 12mm astrometric Illuminated reticle eyepiece plus 2.5x Powermate attached to a Altair Astro 115-mm refractor (focal length 805-mm, f7). The total magnification was 167.5x with a field of view of 0.3 degrees.

All final separation values were calculated from a calibration determined by the timing/transit method (Simple Techniques of Measurement: E.T.H. Teague, Chapter 12 in *Observing and Measuring Visual Double Stars* ed. Argyle, pub. Springer). The final calculated value used was: $12''.49 \pm 0''.04$ per division on the reticle measuring scale. Position Angle measurements were made using the method previously outlined in DSSC 25 which involves using the directional west arrow on the handset to electronically steer the primary to the outer edge of the protractor scale rather than turning off the mount motor for an unaided drift. This has proven to be very reliable and greatly increases the number of measures that can be performed during an evening. As previously stated it relies on as precise polar alignment as possible.

10 separation and 10 position angle measurements (N = 20) were performed on the same evening for each pair and the final results and associated uncertainties calculated. Extensive use was made of the ASTROPLANNER software. Separations throughout the year were limited to a range from 15 arc-seconds to 100 arc-seconds. The faintest magnitude measured was 8.5. These values were out of necessity given the limiting magnification, the high calibration value and the considerable local light pollution. The red light in the eyepiece, even when used at its minimum intensity, also limits the faintest magnitude that can be reasonably measured.

These parameters were set up in the software for whatever constellation was convenient at the date of measurement. All measurements made on any evening were for doubles in close proximity (usually in order of increasing RA) so time was not wasted slewing between distant pairs. This allowed far more measurements to be made than for previous years.

As most of these systems are comparatively wide the orbits are generally very long (1,000 years+) and very few have accurate orbital calculations. Residuals (from the online version of 6th USNO Catalogue of Orbits of Visual Binary Stars) have been given for the few systems calculated but none have a better than grade 4 certainty. Values from the Fourth Catalogue of Interferometric Measurements have provided a more extensive set of residuals but most of these are from 1991 which is 26 years before the author's measurements. Although many of the systems have not changed in this time some have and, in certain cases, this shows in the larger residuals calculated.

Where residuals are large (greater than 1° in PA or 1″ in separation) relative proper motions have been analysed. Any notable differences between the components' proper motions that may explain the larger than average residuals are presented in table 4.

Table 5 presents three alternative, more favourable residuals for three systems that have larger than expected residuals. It should be stressed that these final two tables represent very basic analysis and further professional data and work would be needed to clarify the exact natures and evolving properties of these systems.

References

The Cambridge Double Star Atlas (1st Ed.), (Mullany J. & Tirion W., CUP)
Observing and Measuring Visual Double Stars (ed. Argyle R.W., Springer)
Washington Double Star Catalogue (Mason, B.D., Wycoff, G.L. & Hartkopf, W.I.):
`http://ad.usno.navy.mil/proj/WDS`
Sixth Catalogue of Orbits of Visual Binary Stars (Hartkopf, W.I., Mason, B.D. & Worley, C.E.):
`http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/orb6/sixth-catalog-of-orbits-of-visual-binary-stars`
Fourth Catalogue of Interferometric Measurements of Binary Stars:
`http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/int4`
Astroplanner: `http://www.astroplanner.net/`

Table 1: Measurements

Pair	Comp	WDS	Va	Vb	PA(°)	±	Sep (″)	±	2017+	N	Obs
STTA 254	AB	00013+6021	7.40	8.33	89.2	0.1	58.0	0.2	0.038	20	WST
STF 3053	AB	00026+6606	5.96	7.17	69.6	0.1	15.2	0.1	0.665	20	WST
STTA 1	AB	00141+7601	7.39	7.81	103.3	0.1	73.4	0.3	0.835	20	WST
H 5 17	AB	00369+3343	4.36	7.08	172.5	0.1	35.7	0.2	0.717	20	WST
J 1986	AB	00396+8445	7.96	8.50	68.7	0.1	40.5	0.2	0.835	20	WST
STTA 5		00400+7652	6.86	8.78	141.9	0.1	118.3	0.4	0.038	20	WST
H 5 18	AD	00405+5632	2.35	8.98	282.4	0.1	70.6	0.3	0.038	20	WST
STFA 1	AB	00464+3057	7.25	7.43	46.0	0.1	48.0	0.3	0.717	20	WST
H 582	AB	00474+5106	7.97	8.35	75.0	0.1	57.2	0.2	0.665	20	WST
HJ 2028	AB	01166+7402	7.06	7.88	204.1	0.3	61.5	0.1	0.665	20	WST
H 5 12	AB	01579+2336	4.80	6.65	47.9	0.1	37.2	0.2	0.859	20	WST
STF 222	AB	02109+3902	6.05	6.71	36.0	0.1	16.6	0.2	0.717	20	WST
S 405	AB	02128+7941	6.47	7.15	277.3	0.1	55.6	0.3	0.835	20	WST
STF 239	AB	02174+2845	7.09	7.83	211.6	0.1	13.6	0.1	0.878	20	WST
STTA 26	AB	02197+6002	6.95	7.30	201.0	0.1	62.7	0.3	0.717	20	WST
STTA 27	AB	02268+1034	6.72	8.31	31.2	0.1	73.8	0.3	0.900	20	WST
CTT3	AB	02359+6338	7.78	8.30	88.0	0.1	88.1	0.4	0.717	20	WST
STFA 5	AB	02370+2439	6.50	7.02	275.1	0.1	37.7	0.2	0.900	20	WST
STTA 28	AB	02390+6235	6.65	7.56	147.0	0.1	67.8	0.3	0.717	20	WST
HJ 1123	AB	02420+4248	8.39	8.46	249.7	0.1	20.4	0.2	0.808	20	WST
STT 44	AC	02422+4242	8.47	8.32	289.9	0.1	87.2	0.3	0.808	20	WST
STF 292	AB	02425+4016	7.56	8.23	212.3	0.1	23.5	0.2	0.786	20	WST
STF 307	AB	02507+5554	3.76	8.50	300.5	0.2	30.4	0.3	0.808	20	WST
STTA 31	AB	03009+5940	7.33	8.03	230.8	0.1	74.2	0.3	0.717	20	WST
STTA 33	AC	03221+6244	7.73	7.80	111.9	0.1	114.8	0.4	0.134	20	WST
STFA 7	AB	03311+2744	7.41	7.81	233.9	0.1	44.1	0.2	0.900	20	WST
STT 57	AC	03334+2322	7.17	7.67	33.1	0.1	68.7	0.1	0.900	20	WST
STF 396	AB	03335+5846	6.43	7.68	246.0	0.1	20.7	0.2	0.134	20	WST

S 430	AB	03383+4448	7.21	7.53	96.0	0.1	41.0	0.2	0.808	20	WST
STTA 36	A-BC	03400+6352	6.92	8.27	71.2	0.2	45.8	0.2	0.134	20	WST
STF 434	AB	03440+3822	7.80	8.28	83.0	0.1	34.0	0.2	0.808	20	WST
S 437	A-BC	03463+2411	8.13	7.70	308.2	0.2	38.8	0.2	0.900	20	WST
STFA 8	BC	03475+2406	6.27	8.22	345.0	0.1	86.2	0.1	0.900	20	WST
S 436		03493+5707	6.46	7.17	76.0	0.1	58.3	0.3	0.227	20	WST
STTA 40	AB	03494+2423	6.58	7.53	309.0	0.1	87.4	0.1	0.900	20	WST
STF 485	AE	04078+6220	6.91	6.94	305.2	0.1	17.9	0.2	0.227	20	WST
STTA 45	AB	04155+0611	6.38	7.01	316.0	0.1	63.7	0.1	0.900	20	WST
STTA 44	AB	04173+4613	7.12	7.99	321.3	0.1	58.6	0.2	0.808	20	WST
SHJ 40	AB	04204+2721	5.08	7.51	258.8	0.1	48.7	0.1	0.900	20	WST
S 445	AB	04210+5015	7.31	8.19	328.0	0.1	71.0	0.3	0.808	20	WST
STTA 46	AB	04211+5532	7.68	7.95	159.8	0.1	99.9	0.1	0.227	20	WST
STF 534	AB	04240+2418	6.36	7.94	291.0	0.1	29.4	0.2	0.900	20	WST
STF 533	AB	04244+3419	7.30	8.49	61.2	0.1	20.2	0.2	0.835	20	WST
STF 548		04289+3022	6.44	8.03	35.0	0.1	14.2	0.2	0.900	20	WST
WEB 2	AD	04327+5958	5.72	8.45	36.0	0.1	54.6	0.3	0.134	20	WST
S 451		04363+4722	7.59	7.91	202.0	0.1	55.7	0.3	0.835	20	WST
STTA 53	AB	04374+0034	7.55	7.57	352.0	0.1	78.8	0.3	0.900	20	WST
OPI 5	AC	04382+7128	7.67	8.50	279.3	0.1	111.9	0.4	0.227	20	WST
S 455	AB	04422+2257	4.24	7.02	213.8	0.1	62.5	0.1	0.900	20	WST
S 459	AB	05034+6027	4.12	7.44	209.1	0.1	84.2	0.3	0.227	20	WST
STF 618	AB	05036+6305	7.68	7.98	211.0	0.1	33.3	0.3	0.230	20	WST
STFA 13	AB	05061+5858	5.20	6.21	9.5	0.2	177.7	0.6	0.230	20	WST
STTA 61	AB	05096+2947	6.72	8.49	245.0	0.1	68.4	0.3	0.347	20	WST
STF 698	AB	05252+3451	6.65	8.33	347.0	0.1	31.2	0.1	0.367	20	WST
STFA 63		05308+3950	6.49	7.69	277.0	0.1	75.2	0.3	0.367	20	WST
STTA 72	AC	06247+5940	7.58	7.58	322.6	0.1	134.5	0.5	0.120	20	WST
S 514	AC	06268+5825	5.38	7.92	272.0	0.1	94.9	0.4	0.120	20	WST
SHJ 70	AB	06278+2047	6.65	8.18	201.9	0.1	25.0	0.1	0.271	20	WST
STF 924	AB	06323+1747	6.31	6.88	211.5	0.2	20.7	0.3	0.271	20	WST
S 524	AB	06341+2207	7.17	7.41	244.3	0.2	53.0	0.2	0.295	20	WST
STF 994	AB	06595+3706	7.88	8.14	54.8	0.1	26.4	0.2	0.367	20	WST
HJL 1046	AB	07097+6045	6.76	7.95	164.0	0.1	184.0	0.6	0.120	20	WST
ES 2624		07219+4614	8.12	8.25	87.8	0.1	80.9	0.4	0.120	20	WST
STF 1065		07223+5009	7.51	7.67	254.6	0.2	14.1	0.2	0.120	20	WST
STF 1062	AB	07229+5517	5.76	6.71	315.2	0.3	15.0	0.2	0.131	20	WST
STTA 84	AB	07254+5633	7.72	7.75	322.2	0.1	112.8	0.4	0.131	20	WST
STF 1090	AB	07265+1831	7.27	8.17	98.0	0.1	60.8	0.3	0.295	20	WST
STF 1051	AC	07266+7305	7.60	7.79	84.0	0.1	31.7	0.2	0.230	20	WST
STTA 87		07389+4229	7.59	7.78	357.0	0.1	61.4	0.2	0.131	20	WST
STF 1122		07459+6509	7.78	7.80	184.9	0.1	14.4	0.2	0.230	20	WST
SHJ 86	AB	08025+6305	6.15	7.53	80.0	0.1	50.7	0.2	0.230	20	WST
STTA 91	AB	08195+3503	7.26	8.36	209.5	0.1	94.7	0.3	0.131	20	WST
ES 2631		09056+5018	7.84	8.47	259.0	0.1	78.9	0.4	0.268	20	WST
STF 1315		09128+6141	7.33	7.65	26.9	0.2	24.9	0.1	0.268	20	WST
STF 1321	AB	09144+5241	7.79	7.88	97.1	0.1	17.1	0.3	0.268	20	WST
S 598AB		09287+4536	5.50	7.80	159.7	0.2	69.7	0.3	0.268	20	WST
STF 1369	AB	09354+3958	6.98	7.98	149.0	0.1	25.0	0.1	0.134	20	WST
STF 1369	AC	09354+3958	6.98	8.42	322.9	0.1	116.3	0.4	0.134	20	WST

STF 1369	AC	09354+3958	6.98	8.42	322.9	0.1	116.3	0.4	0.134	20	WST
STF 1369	BC	09354+3958	7.98	8.42	324.0	0.1	141.6	0.5	0.134	20	WST
STF 1399		09570+1946	7.65	8.36	175.9	0.1	30.2	0.2	0.246	20	WST
STF 1415	AB	10178+7104	6.65	7.27	168.0	0.1	16.6	0.2	0.268	20	WST
HZG8AC		11045+3814	6.04	7.56	83.1	0.2	150.1	0.5	0.309	20	WST
S 621	AB	11113+6601	8.31	8.34	53.4	0.1	102.4	0.5	0.309	20	WST
S 621	AC	11113+6601	8.31	8.49	314.0	0.1	166.7	0.6	0.309	20	WST
STF 1516	AB	11152+7329	7.77	8.23	102.9	0.1	67.6	0.3	0.364	20	WST
STF 1540	AB	11268+0301	6.55	7.50	149.1	0.1	28.1	0.2	0.246	20	WST
STFA 19	AB	11279+0251	5.05	7.47	182.0	0.1	88.1	0.3	0.246	20	WST
STF 1565		11396+1900	7.26	8.41	303.9	0.1	22.2	0.1	0.246	20	WST
STTA 112	AB	11545+1925	8.28	8.49	35.1	0.1	73.9	0.3	0.246	20	WST
SHJ 136		12110+8143	6.15	8.25	73.7	0.1	71.9	0.3	0.235	20	WST
STF 1625	AB	12162+8008	7.24	7.78	217.0	0.1	14.2	0.2	0.235	20	WST
STF 1694	AB	12492+8325	5.29	5.74	324.1	0.1	21.8	0.2	0.235	20	WST
STTA 123	AB	13271+6444	6.65	7.03	145.1	0.1	69.2	0.3	0.402	20	WST
STTA 127	AB	13510+6819	6.53	8.32	61.8	0.1	87.4	0.1	0.402	20	WST
STF 1821	AB	14135+5147	4.53	6.62	235.8	0.1	13.1	0.2	0.298	20	WST
STFA 26	AB	14162+5122	4.76	7.39	32.0	0.1	329.0	0.2	0.298	20	WST
STF 1850		14286+2817	7.11	7.56	261.5	0.1	25.1	0.1	0.298	20	WST
SHJ 191		14596+5352	6.86	7.57	341.0	0.1	40.0	0.1	0.298	20	WST
STF 1972	AB	15292+8027	6.64	7.30	80.0	0.1	31.8	0.2	0.835	20	WST
STF 1964	AC	15382+3615	8.07	8.06	86.0	0.1	15.0	0.1	0.298	20	WST
STF 2010	AB	16081+1703	5.10	6.21	12.0	0.1	27.1	0.2	0.386	20	WST
SHJ 233		16315+0818	7.07	8.28	70.8	0.1	59.2	0.3	0.402	20	WST
STFA 30	AC	16362+5255	5.38	5.50	193.3	0.1	90.0	0.3	0.402	20	WST
STFA 30	BC	16362+5255	6.42	5.50	194.0	0.1	90.1	0.4	0.402	20	WST
STF 2079		16396+2300	7.56	8.13	90.6	0.1	16.7	0.2	0.386	20	WST
STFA 31	AB	16406+0413	5.76	6.92	229.0	0.1	69.3	0.4	0.400	20	WST
STTA 149		16435+2043	7.24	8.38	134.7	0.1	97.4	0.3	0.386	20	WST
S 689AB		17246+3913	7.48	8.44	197.0	0.1	89.2	0.4	0.400	20	WST
STFA 35		17322+5511	4.87	4.90	311.2	0.2	62.1	0.2	0.402	20	WST
STF 2241	AB	17419+7209	4.60	5.59	15.5	0.1	30.5	0.2	0.402	20	WST
STTA 163	AB	17562+6237	7.77	7.59	53.0	0.1	54.3	0.3	0.416	20	WST
STF 2259		17590+3003	7.27	8.44	277.0	0.1	19.5	0.2	0.400	20	WST
STF 2273	AB	17592+6409	7.31	7.63	283.3	0.2	22.0	0.2	0.416	20	WST
STF 2308	AB	18002+8000	5.70	6.00	230.2	0.1	18.7	0.3	0.416	20	WST
STF 2278	AB	18029+5626	7.78	8.14	29.0	0.1	36.3	0.1	0.441	20	WST
STF 2278	AC	18029+5626	7.78	8.53	38.0	0.1	34.3	0.2	0.441	20	WST
H 5 93		18130+2815	8.16	8.28	136.0	0.1	54.7	0.2	0.400	20	WST
STF 2323	AC	18239+5848	5.06	7.95	19.0	0.1	89.1	0.3	0.441	20	WST
STF 2323	BC	18239+5848	8.07	7.95	19.5	0.1	86.5	0.3	0.441	20	WST
STF 2372	AB	18421+3445	6.45	7.73	82.0	0.1	25.0	0.1	0.517	20	WST
STFA 38	AD	18448+3736	4.34	5.62	150.0	0.1	43.7	0.1	0.517	20	WST
STFA 39	AB	18501+3322	3.63	6.69	148.8	0.1	45.7	0.3	0.517	20	WST
STTA 176	AB	18545+0154	7.45	7.51	111.7	0.1	94.0	0.4	0.649	20	WST
SHJ 282	AC	18549+3358	6.14	7.60	349.0	0.1	45.6	0.3	0.517	20	WST
STF 2420	AB	18512+5923	4.77	8.26	317.0	0.1	37.5	0.1	0.441	20	WST
STF 2474	AB	19091+3436	6.78	7.88	263.7	0.1	15.5	0.2	0.517	20	WST
STTA 177	AC	19126+1651	7.11	8.02	276.0	0.1	98.4	0.4	0.654	20	WST

STTA 178		19153+1505	5.69	7.64	267.9	0.1	89.6	0.3	0.649	20	WST
STTA 181	AB	19201+2639	7.39	7.50	359.0	0.1	62.8	0.3	0.517	20	WST
STFA 43	AB	19307+2758	3.19	4.68	54.0	0.1	35.0	0.2	0.550	20	WST
STF 2549	AD	19312+6319	8.34	8.03	269.7	0.3	55.6	0.3	0.441	20	WST
STFA 44		19332+6010	6.47	8.19	287.0	0.1	74.9	0.1	0.441	20	WST
ARN 82	AB	19364+3541	8.10	8.43	34.1	0.1	43.5	0.2	0.564	20	WST
H 626	AB	19373+1628	5.77	8.35	82.2	0.1	87.4	0.1	0.654	20	WST
STFA 46	AB	19418+5032	6.00	6.23	132.5	0.1	39.9	0.2	0.564	20	WST
STTA 188	AB	19428+3741	7.71	7.98	121.0	0.1	61.1	0.2	0.564	20	WST
H 5 137	AB	19459+3501	6.22	8.18	24.0	0.1	37.7	0.2	0.564	20	WST
STFA 48	AB	19534+2020	7.14	7.34	147.0	0.1	41.8	0.2	0.649	20	WST
AC 16	AC	19579+2715	7.81	7.97	136.0	0.1	92.3	0.1	0.649	20	WST
STTA 200	AB	20023+6438	6.36	8.06	332.3	0.2	99.3	0.4	0.441	20	WST
ES 25	AF	20060+3546	7.89	6.78	329.0	0.1	95.7	0.4	0.578	20	WST
SHJ 314	AF	20060+3547	6.78	7.30	28.0	0.1	36.2	0.1	0.578	20	WST
WEB 12	AB	20078+1950	8.36	8.37	77.0	0.1	40.4	0.2	0.654	20	WST
HJ 606	AB	20084+3808	7.98	8.12	228.5	0.1	44.0	0.2	0.578	20	WST
STF 2637	AC	20099+2055	6.56	7.52	221.5	0.1	91.8	0.4	0.654	20	WST
S 738	AB	20106+3338	7.76	8.43	105.5	0.1	41.3	0.3	0.578	20	WST
STF 2664	AB	20196+1300	8.07	8.34	321.2	0.1	27.1	0.2	0.654	20	WST
STTA 207	AC	20229+4259	6.41	8.01	64.6	0.1	85.8	0.3	0.578	20	WST
STF 2687	AB	20264+5638	6.37	8.31	117.5	0.1	25.5	0.2	0.578	20	WST
STF 2691	AB	20297+3808	8.14	8.45	31.0	0.1	17.0	0.2	0.578	20	WST
STF 2690	A-BC	20312+1116	7.12	7.39	255.8	0.1	17.7	0.2	0.654	20	WST
STF 2703	AB	20368+1444	8.35	8.42	289.0	0.1	25.0	0.1	0.654	20	WST
STTA 211	AB	20493+5845	6.85	7.88	268.0	0.1	95.0	0.3	0.835	20	WST
STF 2758	AB	21069+3845	5.20	6.05	152.4	0.2	31.8	0.2	0.578	20	WST
BU 69	AC	21026+2141	8.35	8.02	241.0	0.1	74.6	0.3	0.649	20	WST
STF 2769	AB	21105+2227	6.65	7.42	299.0	0.1	18.7	0.1	0.649	20	WST
STFA 56	AB	21377+0637	6.18	7.50	348.0	0.1	39.0	0.2	0.788	20	WST
GUI 36	CD	21390+5729	7.48	7.53	324.3	0.1	30.7	0.2	0.835	20	WST
STF 2816	AD	21390+5729	5.73	7.53	338.9	0.1	20.4	0.2	0.848	20	WST
STT 447	AE	21395+4144	7.67	8.48	44.3	0.1	28.9	0.2	0.578	20	WST
STTA 222	AB	21441+0709	7.49	8.47	257.4	0.1	87.4	0.1	0.788	20	WST
ES 382	AC	21509+3240	8.28	8.42	322.0	0.1	58.3	0.4	0.788	20	WST
STF 2840	AB	21520+5548	5.64	6.42	196.3	0.1	18.0	0.2	0.846	20	WST
S 800	AB	21538+6237	7.07	7.91	145.0	0.1	62.5	0.1	0.846	20	WST
STF 2841	A-BC	21543+1943	6.45	7.99	108.0	0.1	22.2	0.2	0.786	20	WST
ARY 45	AB	22083+6959	7.86	8.11	206.9	0.1	66.6	0.2	0.846	20	WST
STF 2872	A-BC	22086+5917	7.14	7.98	315.0	0.1	22.4	0.1	0.846	20	WST
STF 2893	AB	22129+7318	6.19	7.91	347.2	0.1	29.2	0.2	0.846	20	WST
STTA 234	AC	22269+4943	8.15	8.49	133.7	0.1	36.3	0.1	0.657	20	WST
STFA 58	AC	22292+5825	4.21	6.11	190.8	0.1	40.6	0.2	0.846	20	WST
STF 2922	AB	22359+3938	5.66	6.29	185.0	0.1	22.4	0.1	0.657	20	WST
STTA 236	AB-D	22361+7253	7.56	8.42	136.0	0.1	42.7	0.2	0.848	20	WST
BU 277	AB-D	22395+4123	8.26	8.50	47.0	0.1	78.1	0.3	0.657	20	WST
HJ 1823	AC	22518+4119	7.06	8.11	337.5	0.1	81.6	0.3	0.657	20	WST
STTA 238	AB	22527+6759	7.02	7.58	280.0	0.1	69.2	0.3	0.848	20	WST
STTA 241	AB	22586+1203	8.28	8.37	160.3	0.1	84.9	0.4	0.788	20	WST
S 825	AB	23100+3651	7.78	8.26	318.0	0.1	67.1	0.3	0.717	20	WST

STF 2985	AB	23100+4758	7.21	8.02	256.2	0.1	15.4	0.2	0.717	20	WST
STTA 245	A-BC	23260+2742	7.92	8.50	194.8	0.1	62.5	0.1	0.788	20	WST
SHJ 355	AC	23300+5833	4.87	7.23	268.6	0.2	74.9	0.1	0.717	20	WST
STF 3041	A-BC	23479+1703	8.35	8.36	358.0	0.1	60.5	0.3	0.786	20	WST
STT 507	AC	23487+6453	6.76	8.44	349.2	0.1	50.0	0.1	0.717	20	WST
STF 3044	AB	23530+1155	7.27	7.91	282.5	0.1	18.7	0.1	0.788	20	WST

Table 2: Residuals from Known Orbits

Pair		ADS (HIP)	Residuals		Orbit	(yrs)	Date	Grade
STF 1321	AB	7251	−1.4	+0.3	Chang	975	1972	4
STF 1540	AB	8162	+2.3	−0.5	Hopmann	32,000	1960	5
STF 1821	AB	9173	+0.5	−0.7	Kiyaeva	6,100	2006	5
STF 1821	AB	9173	+1.0	−1.1	Kiyaeva	6,600	2006	5
STF 2241	AB	10759	−1.3	+0.9	Kiselev	10,000	2009	5
STF 2308	AB	11061	−1.1	−0.1	Kiselev	18,000	1996	5
STFA 46	AB	12815	−0.6	+0.1	Marcy	13,500	1999	4
STF 2758	AB	14636	+0.3	+0.1	PKO	600	2006	4
S 825	AB	16558	−0.7	+0.3	Kiselev	110,000	2009	5
S 825	AB	16558	−1.8	+0.3	Kiselev	98,000	2009	5
S 825	AB	16558	−0.8	−0.1	Kiselev	98,000	2009	5

(All Residuals: Observed – latest Catalogue measurement

Table 3: Residuals from Fourth Catalogue of Interferometric Measurements

Pair		ADS (BDS)	HIP (TYC)	Epoch (cat.)	$\Delta\theta$ (°)	$\Delta\rho$ (″)
STTA 254	AB	(12693)	99	1991.61	−0.2	+0.2
STF 3053	AB		207	2003.770	−0.6	+0.2
STTA 1	AB		1124	1991.67	−0.2	−0.5
H 5 17	AB	513	2912	2003.804	−0.9	−0.2
HJ 1986	AB		(4619 00293)	1991.69	+1.8	+0.1
STFA 1	AB	639	3617	2003.804	−0.3	+0.9
STTA 5		(345)	BD+76 14	1991.73	−0.1	+0.6
H 5 18	AD	561	3179	1991.57	+0.5	+1.5
H 582	AB	(417)	3698	1991.76	−0.1	+1.8
HJ 2028	AB		5950	1991.67	+0.4	+0.1
H 5 12	AB	1563	(1757 01964)	1993.918	+0.8	+0.5
STF 222	AB	1683	10176	2003.875	+0.1	+0.1
S 405			10309	1991.73	+0.5	−0.1
STF 239	AB	1752	10680	1991.85	+0.1	−0.2
STTA 26	AB		10856	1991.56	+0.7	−0.7
STTA 27	AB		11390	1991.78	−0.7	+0.2
CTT3	AB		12081	1991.66	+0.1	+0.6
STFA 5	AB	1982	12189	1991.70	+0.6	−0.5

STTA 28	AB		16218	1991.56	−0.4	+0.0
HJ 1123	AB	2048	(2853 00022)	1991.79	+1.1	+0.3
STT 44	AC	2052	12619	1991.73	−0.1	+0.9
STF 292	AB	2057	12648	1991.70	+0.8	+0.5
STF 307	AB					
STTA 31	AB		14049	1991.71	+0.6	+0.6
STTA 33	AC		15686	1991.63	+0.8	−1.4
STFA 7	AB		16386	2004.115	+0.3	+0.8
STT 57	AC	2605	(1798 00480)	1991.57	−0.7	−1.0
STF 396	AB	2592	16587	2004.115	+1.7	+0.6
S 430	AB		16972	1991.64	+0.1	−0.1
STTA 36	A BC	2650	17118	1991.66	+0.4	−0.1
STF 434	AB	2717	17424	1991.64	−0.2	+1.0
S 437	AB C	2755	(1800 01961)	1991.64	+0.5	−0.2
STFA 8	BC		(1800 02201)	1991.68	+0.7	+0.8
S 436			17858	1991.70	+0.1	−0.1
STTA 40	AB		17862	1991.57	+0.1	+0.5
STF 485	AE	2984	19272	2008.0479	+0.4	+0.1
STTA 45	AB	3085	19859	1991.63	+0.3	−0.7
STTA 44	AB		20000	1991.55	−1.3	+0.3
SHJ 40	AB	3137	20250	1991.60	+3.3	−0.4
S 445	AB		20296	1991.56	0.0	−0.8
STTA 46	AB		20306	1991.42	0.0	+0.3
STF 534	AB	3179	20533	2002.901	+0.7	+0.7
STF 533	AB	3185	20570	2002.977	−0.1	+0.6
STF 548	AB	3243	20904	2012.6779	−0.9	−0.3
S 451			21437	1991.60	+0.5	−0.4
STTA 53	AB		21534	1991.58	−1.0	+0.8
OPI 5	AC		21578	1991.7	+0.1	+0.1
S 455	AB		21881	1991.56	+0.4	−0.4
S 459	AB	3615	23527	1991.64	0.0	+1.1
STF 618	AB		23532	1991.57	−0.4	+0.5
STFA 13	AB		23734	1991.7	+0.5	−1.0
STTA 61	AB		24016	1991.65	+0.5	−0.5
STF 698	AB	4000	25343	2002.884	−0.2	0.0
STFA 63			25810	1991.66	+0.8	−0.7
STTA 72	AC		(3776 01181)	1991.63	−0.2	+0.3
S 514		5036	30679	1991.67	0.0	−0.6
SHJ 70	AB	5080	30757	2002.901	−0.5	+0.0
STF 924	AB	5166	31158	2002.91	+0.6	+1.0
S 524 AB			31323	1991.85	+0.2	−0.5
STF 994	AB	5642	33649	1991.72	−0.4	−0.4
HJL 1046		5810	34572	1991.68	−1.3	+1.8
ES 2624			35684	1991.85	+0.6	−0.1
STF 1065		6004	35731	1991.86	0.0	−0.8
STF 1062	AB	6012	35785	2002.996	−0.5	+0.3
STTA 84	AB		36026	1991.62	−0.7	−0.7
STF 1090	AB	6073	36122	1991.72	−0.1	+0.0
STF 1051	AC	6028	36132	1991.76	+0.4	+0.3
STTA 87			(2966 00032)	1991.76	−0.3	−0.9

STF 1122		6319	(4121 01516)	1991.82	−1.3	−0.5	
SHJ 86	AB		39340	1991.79	−0.5	−0.2	
STTA 91	AB		40791	1991.7	−2.9	+0.8	
ES 2631			44628	1991.79	+0.3	−0.5	
STF 1315		7226	45206	1991.59	0.0	+0.1	
STF 1321		7251	45343	1991.81	+6.6	−0.4	
S 598			46471	1991.75	−1.4	−2.8	
STF 1369	AB	7438	47053	2003.311	−0.9	+0.1	
STF 1369	AC	7438	47053	1991.85	0.0	−0.4	
STF 1369	BC	7438	47054	1991.86	+0.1	−0.1	
STF 1399		7589	48785	1991.50	+0.6	−0.3	
STF 1415		7705	50433	2003.251	+0.7	+0.1	
HZG 8 AC		8046	54136	1991.62	+0.4	−0.2	
S 621 AB			54657	1991.72	+1.6	+6.9	
S 621 AC			54657	1991.73	+2.1	−4.0	
STF 1516	AB	8100	54952	1991.77	−0.3	+10.2	(1)
STF 1540	AB		55846	1991.68	−0.6	−0.3	
STFA 19	AB		55945	1991.76	+1.9	−1.1	
STF 1565			56875	1991.61	−0.5	+0.6	
STTA 112	AB		58067	1991.75	−0.4	+0.5	
SHJ 136			59384	1991.69	−0.7	+1.6	
STF 1625	AB	8494	59836	1991.64	−1.4	−0.2	
STF 1694	AB	8682	62572	2003.284	−2.2	+0.5	
STTA 123	AB		65603	1991.63	−1.5	+0.2	
STTA 127	AB		67589	1991.69	−1.1	+2.3	
STF 1821	AB	9173	69483	2008.278	+0.3	−0.5	
STFA 26	AB	9198	69713	2003.251	−0.3	+0.3	
STF 1850		9277	79786	1991.71	+0.2	−0.3	
SHJ 191		9474	73366	1991.59	−0.8	−0.3	
STF 1972	AB	9696	75809	1991.69	+0.8	+0.5	
STF 1964	AC	9731	76563	2015.400	−0.1	+0.0	
STF 2010	AB	9933	79043	2003.418	−1.0	−0.3	
SHJ 233			80926	1991.55	+0.1	+0.1	
STFA 30	AC	10129		1991.68	−0.1	−0.2	
STFA 30	BC	10129		1991.25	Suspect Catalogue Figure??		(2)
STF 2079		10146	81575	1991.82	+0.1	−0.1	
STFA 31	AB	10149	81641	1991.47	−0.4	−0.4	
STTA 149			81880	1991.64	+0.3	+0.4	
S 689 AB			85201	1991.70	+0.4	−0.5	
STFA 35		10628	85829	1999.4	0.0	−0.1	
STF 2241	AB	10759	86614	1991.7	0.0	+0.3	
STTA 163	AB		87815	1991.64	+3.0	−0.4	
STF 2259		10955	88055	1991.61	−0.3	−0.2	
STF 2273	AB	10985	88071	1991.77	+0.1	+0.7	
STF2308	AB	11061	88136	2012.7725	+0.2	−0.8	
STF 2278	AB	11035	165502	1991.60	+1.0	+0.1	
STF 2278	AC	11035	165502	1991.62	+0.9	+0.5	
H 5 93			89270	1991.65	+0.1	−0.4	
STF 2323	AC	11336	90156	2000.29	−0.5	+0.4	
STF 2323	BC	11336	(3916 01982)	1991.41	−1.5	+0.9	

STF 2372	AB	11593	91707	2003.418	0.0	+0.2	
STFA 38	AD	11639	91971	2003.418	−0.3	−0.1	
STFA 39	AB	11745	92420	1991.49	−0.6	0.0	
STTA 176	AB		92794	1991.81	−0.9	−0.7	
SHJ 282	AC	11834	92833	2003.697	−0.4	+0.6	
STF 2420	AB	1179	92512	2003.628	−2.4	+1.0	
STF 2474	AB	12101	94076	2013.5533	+2.0	−0.6	
STTA 177	AC	12160	94377	1991.50	−2.5	−3.1	
STTA 178			94624	1991.57	+0.9	−0.2	
STTA 181	AB		95028	1991.62	−1.3	+1.1	
STFA 43	AB	12540	95947	2003.418	+0.5	+0.6	
STF 2549	AD	12586	96002	1991.76	−1.2	+1.0	
STFA 44			96164	1991.63	+0.6	−0.4	
ARN 82	AB		(2667 00321)	1991.61	−0.3	+0.2	
H 626	AB	12693	96516	1991.69	+0.5	−0.7	
STFA 46	AB	12815	96895	2003.628	−1.2	+0.8	
STTA 188	AB		96986	1991.64	−0.1	+0.8	
H 5 137	AB	12900	97242	2003.628	−1.0	−0.5	
STFA 48	AB		97876	1991.69	+0.2	−0.3	
AC 16	AC	13176	98248	1991.67	+0.2	−1.0	
STTA 200	AB		98658	1991.73	−0.9	+0.7	
ES 25	AF	13376	(2683 03586)	1991.61	−0.2	−0.1	
SHJ 314	AF	13374	99002	2003.695	+0.3	+1.5	
WEB 12	AB		(1625 00995)	1991.703	+0.2	−0.6	
HJ 606	AB		99196	1991.66	+0.3	−0.1	
STF 2637	AC	13442	99352	1991.65	−0.5	+3.3	
S 738	AB	13463	99409	1991.61	−1.6	−0.6	
STF 2664	AB		100226	1991.49	−0.3	−0.5	
STTA 207	AC	13786	100515	1991.70	+0.3	−1.7	
STF 2687	AB	13870	100808	2003.629	+0.2	−0.3	
STF 2691	AB	13919	101109	1991.68	−0.4	−0.2	
STF 2690	A-BC	13946	101233	1991.52	+1.0	+0.5	
STF 2703	AB		101700	1991.64	−1.1	−0.3	
STTA 211	AB		102775	1991.72	+1.7	−2.9	
STF 2758	AB	14636	104214	1991.69	+4.4	+1.7	(3)
BU 69	AC	14570	103852	1991.44	+0.6	−0.5	
STF 2769	AB	14710	104539	2003.784	−0.2	+0.8	
STFA 56	AB	15147	106783	2003.629	−0.6	+0.4	
GUI 36	CD	15184	106890	2003.620	−0.3	+0.9	
STF 2816	AD	15184	106886	2003.620	+0.2	+0.7	
STT 447	AE	15186	(3191 00346)	1991.67	−0.3	0.0	
STTA 222	AB		(0555 00887)	1991.88	0.0	−0.2	
ES 382	AC	15377	107844	1991.82	−0.2	−0.3	
STF 2840	AB	15405	107930	2003.621	+0.6	+0.3	
S 800	AB	15434	108073	1991.61	−0.1	+0.0	
STF 2841	A BC	15431	108119	2003.784	−1.7	+0.2	
ARY 45	AB		109275	1991.67	+0.3	+0.0	
STF 2872	A-BC	15670	(3981 01587)	1991.68	−0.9	+1.2	
STF 2893	AB	15764	109659	2003.629	+0.2	+0.4	
STTA 234	AC	15951	(3615 00740)	1991.67	−0.2	+0.0	

STFA 58	AC	15987	110991	2003.629	−0.2	+0.1
STF 2922	AB	16095	111546	2003.625	−0.2	+0.2
STTA 236	AB-D	16111	111570	1991.74	−0.8	+0.5
BU 277	AB-D	16153	(3209 00191)	1991.63	−0.3	+0.5
HJ 1823	AC	16321	112905	1991.68	+0.2	−0.4
STTA 238	AB		112970	1991.72	−0.3	−0.0
STTA 241	AB		11344	1991.66	−0.4	+0.3
S 825 AB		16558	218741	1991.76	−0.5	−0.1
STF 2985	AB	16557	114385	2012.6746	+0.5	−0.4
STTA 245	AB-C	16748	115666	1991.64	+0.3	−0.6
SHJ 355	AC	16795	115990	1991.59	−0.2	−0.7
STF 3041	A-BC	17009	117366	1991.52	+1.6	−1.0
STT 507	AC	17020	117430	2003.629	−1.1	0.0
STF 3044	AB	17079	117768	1991.62	+0.2	−0.5

Table 4: Doubles with significant proper motion differences

Pair	Comp	epoch	μ_α	μ_δ	μ_α	μ_δ	$\Delta\theta$	$\Delta\rho$
HJ 1986	AB	1991	+050	+021	+079	−024	+1.8	+0.1
H 5 18	AD	1991	+051	−032	−002	−003	+0.5	+1.5
H 5 82	AB	1991	−026	−024	+017	+004	−0.1	+1.8
SHJ 40	AB	1991	−029	−078	−001	−001	+3.3	−0.4
S 459	AB	1991	−006	−015	−014	−035	0.0	+1.1
STFA 13	AB	1991	−007	−008	−004	−027	+0.5	−1.0
HJL 1046	AB	1991	−009	−048	−013	−058	−1.3	+1.8
STTA 91	AB	1991	−055	−005	+088	−139	−2.9	+0.8
STF 1321	AB	1991	−153	−056	−155	−066	+6.6	−0.4
S 598		1991	−022	−012	−090	−016	−1.4	−2.8
S 621	AB	1991	−334	−124	+007	−002	+1.6	+6.9
S 621	AC	1991	−334	−124	+000	−001	+2.1	−4.0
STF 1516	AB	1991	−402	+110	+001	−002	−0.3	+10.2
STFA 19	AB	1991	+016	−010	−090	+017	+1.9	−1.1
STTA 127	AB	1991	−176	−058	−104	+011	−1.1	+2.3
STF 2010	AB	2003	−034	−006	−026	−032	−1.0	−0.3
STTA 163	AB	1991	−053	+099	+011	−014	+3.0	−0.4
STF 2278	AB	1991	−021	+039	+004	+013	+1.0	+0.1
STF 2278	AC	1991	−021	+039	+001	+012	+0.9	+0.5
STF 2420	AB	2003	+078	+025	+000	+000	−2.4	+1.0
STTA 177	AC	1991	+002	−012	+125	−196	−2.5	−3.1
STTA 181	AB	1991	+013	−053	−021	+010	−1.3	+1.1
STF 2549	AD	1991	+041	+020	−006	−009	−1.2	+0.2
STF 2637	AC	1991	+059	+098	+005	−056	−0.5	+3.3
STF 2637	AC	1991	+059	+098	+005	−056	−0.5	+3.3
S 738	AB	1991	−011	−017	+001	+001	−1.6	−0.6
STTA 207	AC	1991	+056	+043	−003	−018	+0.3	−1.7
STTA 211	AB	1991	−004	−002	+131	+100	+1.7	−2.9
STF 3041	AB-C	1991	+017	−010	+083	−078	+1.6	−1.0

All Proper Motions: WDS 2017

Table 5 : Alternative Residuals

Note	Pair	Catalogue (date)	Residuals (O-C)	
(1)	STF 1516 AB	Fourth Interferometric (1991)	−0.3	+10.2
		WDS (2015)	−1.1	0.0
(2)	STFA 30 BC	Fourth Interferometric (1991)	*	0.0
		WDS (2015)	−3.0	−1.4
(3)	STF 2758 AB	Fourth Interferometric (1991)	+4.4	+1.7
		WDS (2016)	+0.2	+0.4

* Fourth Interferometric Catalogue gives a PA of 15°.5. WDS (2015) gives 197″ and NW measured 194″ .

ASTROMETRIC AND PHOTOMETRIC MEASUREMENTS OF THE DOUBLE STAR J703 (WDS07016+1543)

André Debackère Double Star Commission, Société Astronomique de France

E-mail:andre.debackere@free.fr

Abstract

I report CCD astrometric and photometric measurements of the components of the double star system WDS 07106+1543 (J 703) using the LCO T0.4m telescope at the McDonald Observatory, Fort Davis, Texas, USA. Combined with historical observations, our measurements suggest that the existing fitted orbital solution may be premature.

Introduction

My interest in double stars discovered by Robert Jonckheere led me to select[1] those classified as "orbitals" in the WDS (Washington Double Star Catalog)[2]. In particular the pair J 703 which has been the subject of observations since its discovery in 1912 during a little over a century. Jonckheere indicates in his General Catalog of 3350 double stars of low brightness observed from 1906 to 1962, page 133: "to + 5s of the BD + 15° 1490 (9.3), retrograde movement of 30° ". An orbit was proposed by Z. Cvetkovic in 2008.

I. Images

I used 12 CCD images from November 30, 2017 (6 images taken with a SDSS g' filter and six more taken with a SDSS r' filter) acquired at the 0.40m diameter telescope of the McDonald Observatory located in Fort Davis, Texas , USA. These images can be downloaded from the LCO website[3].

II. Astrometry

Measures on the images

a) Use of the ASTROMETRICA software[4]

I used the 6 images taken with the SDSS g' filter Determination of the equatorial coordinates (J 2000.0) of the two components A and B of the double star J 703 using the software and the GAIA-DR15 catalog.

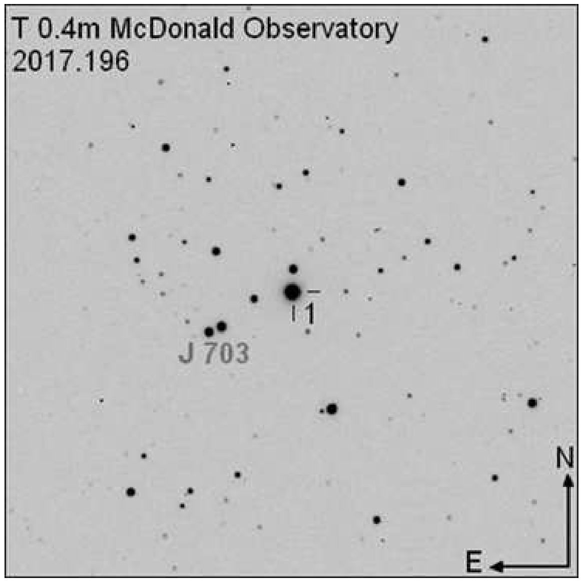

Figure 1: J 703 near the bright star 529-038229 (UCAC4)

A:	RA: 07h 10m 37s.90	± 0″.08	Dec: +15° 43′ 14″.1	± 0″.09
B:	RA: 07h 10m 37s.22	± 0″.08	Dec: +15° 43′ 18″.3	± 0″.09

θ: 293°.16 ±0°.69 ρ: 10″.679 ±0″.120 2017.196

b) Using the REDUC software[6]

The calibration of images with two stars of the field identified in the UCAC47 catalog (star UCAC4 530-038988 and star UCA4 530-038994) gives a sensor orientation Δ = 0°.83 (relative to the direction of the North by turning positively towards the East) and a sampling of the digital images E = 1″.13675 /pix. The reduction with SURFACE gives polar coordinates:

θ: 292°.83 ±1°.21 ρ: 10″.719 ±0″.083 2017.196

Using the 2MASS[8] and GAIA-DR1 catalogs

Calculation of the polar coordinates of J 703 from the equatorial coordinates of the components provided by the 2MASS catalog.

A:	07h 10m 37s.926	±0″.08	+15° 43′ 14″.30	±0″.06
B:	07h 10m 37s.355	±0″.08	+15° 43′ 18″.13	±0″.06

θ: 294°.93 ±0°.61 ρ: 9″.087 ±0″.100 1997.8

in accordance with the TMA 2003 reference in data provided by William Hartkopf (USNO Double Star data for WDS 07106+1543).

Calculation of the polar coordinates of J 703 from the equatorial coordinates of the components provided by the GAIA-DR1 catalog:

A:	07h 10m 37s.9067	±0″.000148	+15° 43′ 14s.183	±0″.000171
B:	07h 10m 37s.2370	±0″.000137	+15° 43′ 18s.374	±0″.000154

θ: 292°.83 ±0°.001 ρ: 10″.719 ±0″.0002 2015.0

Calculation of the proper motions

I compare the equatorial coordinates J 2000.0 of the two components of the pair given by the 2MASS catalog and the Gaia-DR1 catalog.

2MASS catalog (1997.8) - Equatorial coordinates (J 2000.0)

07h 10m 37s.926	±0″.08	+15° 43′ 14″.30	±0″.06
07h 10m 37s.355	±0″.08	+15° 43′ 18″.13	±0″.06

Gaia-DR1 catalog (2015.0) - Equatorial coordinates (J 2000.0)

07h 10m 37s.9067	±0″.000148	+15° 43′ 14s.183	±0″.000171
07h 10m 37s.2370	±0″.000137	+15° 43′ 18″.374	±0″.000154

Proper motions

A:	-0″.2755	±0″.0818	-0″.1135	±0″.0600	B:	-1″.7037	±0″.0817	-0″.2472	±0″.0600
A:	0″.298	±0″.101	247°.6	±1°.5	B:	1″.722	±0″.101	278°.3	±1°.3

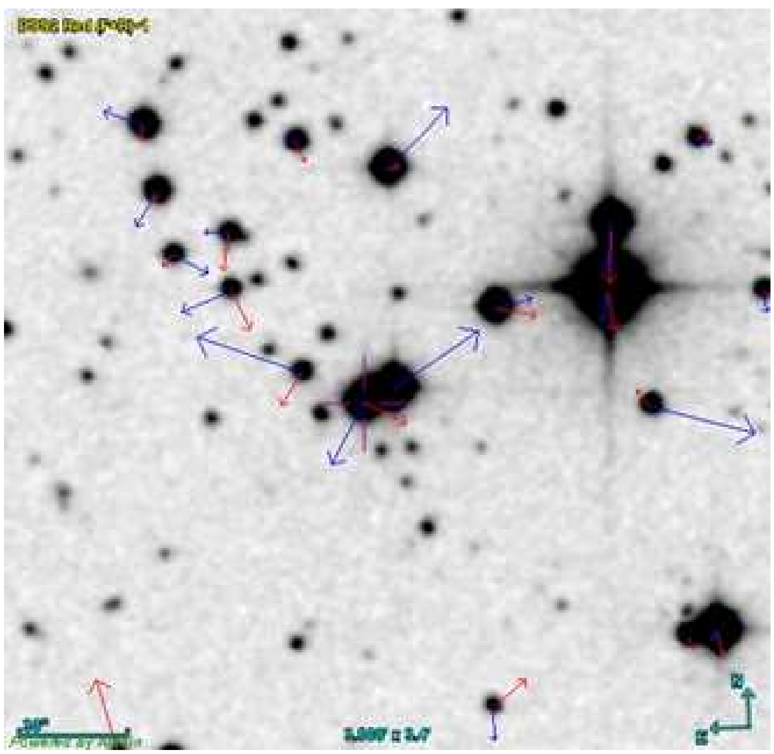

Figure 2: J 703. Proper motions from UCAC4 (blue) and those from GAIA-DR1(red)

In blue the proper motions given by the UCAC4 and in red those given by GAIA-DR1. The proper motion of A that I calculated previously corresponds to the proper motion given by GAIA-DR1.The proper motion of B is not in GAIA-DR1. The parallaxes of the two components are not known. The 2nd component has a much larger movement than that of the main component which suggests that: either the two components are at very different distances, or the two components are linked by gravitation, a hypothesis envisaged by Cvetkovic and Ninkovic in 2008 as the couple appearing in the *Sixth Catalog of Visual Binary Orbits* (Hartkopf *et al.*, 2015[9] but with grade 5 (indeterminate orbit: the elements may not even be approximately correct. The observed arc is usually too short, with little curvature, and frequently there are large residuals associated with the computations).

Orbital elements (J 703)

	P	a	i	Ω	T	e	ω	G	Reference
	1360.2	12.70	113.4	96.2	3235.4	0.850	177.1	5	Cve2008d
±	62.9	0.59	0.5	0.8	4.2	0.042	2.4		

P: period in years, a: semi-major axis in arcseconds, i: inclination in degrees, Ω: position angle of the node in degrees, T: time of periastron passage in years, e: eccentricity, ω: longitude of periastron, in degrees, G: grade

Orbital ephemerides

Name	Grade	Reference	θ 2016.0	ρ 2016.0	θ 2017	ρ 2017	θ 2018	ρ 2018	θ 2019.0	ρ 2019.0
J 703	5	Cve2008d	112.9	9.939	112.8	9.999	112.8	10.059	112.7	10.118

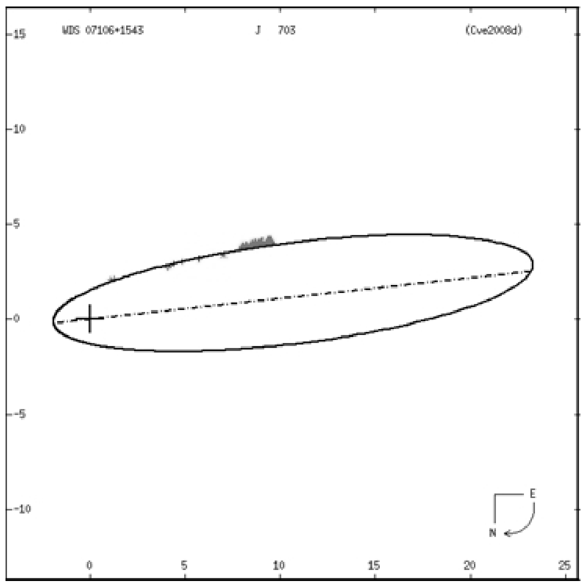

Figure 3: Apparent orbit of J703 (WDS07106+1543) from WDS Sixth Orbit catalogue

III. Photometry

Aperture photometry with the Makali'i Subaru Image Processor10 software and the APASS11 catalog. The filters used to take the images are the SDSS12 g' (mean λ: 477.0 nm, width 150.0 nm) and the SDSS r' (mean λ 621.5 nm, width 139.0 nm. I chose five reference stars identified in the UCAC4 catalog and whose magnitudes in g' and r' bands are provided by the APASS catalog.

Star number	UCAC4 Catalog Identification	APASS Catalog g' magnitude	APASS Catalog r' magnitude
1	529-038272	13.506	12.585
2	529-038236	13.502	13.121
3	529-038248	13.275	12.846
4	529-038262	13.662	13.210
5	529-038289	12.198	10.801

Software settings: circles values for photometry $R_1 = 4$ pixels (circle surrounding the star), $R_2 = 20$ pixels (radius of the inner circle on the sky) and $R_3 = 10$ pixels (width of the gap between the outer circle and the inner circle on the sky).

g' mag	r' mag	g' mag	r' mag	IC $(g'-r')$	IC $(g'-r')$
11.931	11.895	12.152	11.622	0.036	0.530
±0.099	±0.021	±0.095	±0.051	±0.101	±0.108

The star A is brighter than B in g' band but A is less brilliant than B in r' band. The magnitudes of A and B being close this can explain the quadrant inversion during the discovery in 1912 and the following measurements (General catalogue of 3350 double low-light stars observed from 1906 to 1962 by Robert Jonckheere). I did not find any variability for these components in the variable star catalogs or on the AAVSO[13] website.

Recapitulation

USNO Double Star data for WDS 07106+1543

Epoch	θ	ρ	mA	e_{mag}	mB	e_{mag}		Aper	N	Obs	Met	N	
1912.01	q333.1	2.31	9.7		9.7			0.4	1	J	Ma		3
1912.01	q329.3	2.51	9.6		9.6			0.4	1	Vdk	Ma		3
1949.74	303.8	5.28						2.1	4	VBs	Mb	I	0
1952.15	q303.9	4.91	9.8		9.8			0.4	2	Cou	Ma		0
1957.31	302.1	5.74			0.1			0.3	3	Wor	Ma		0
1962.953	q298.9	6.56						0.9	1	VBs	Mb		2
1965.122	q299.2	6.53						2.1	2	VBs	Mb		2
1983.095	q295.81	7.806						1	1	Tor	Po		4
1997.68q	295.0	8.85						0.4	1	Elt	C		5
1997.82	294.9	9.09	11.07	0 22	9.908	0.02	125	245 1.3	1	TMA	E		
1997.82			10.85	0.02	9.335	0.01	163	160 1.3	1	TMA	E2		7
1997.82			10.78	0.01	9.204	0.01	221	300 1.3	1	TMA	E2		7
2000.97	294.7	9.368	11.98	0.08	11.57	0.02	60	70f 0.2	7	UC	Eu	P	7
2002.869	294.5	9.522					60	70 0.2	4	UC	Eu		7
2006.9583	293.86	9.736						2	1	Pop	C		7
2006.9583	294	9.869						2	1	Cve	C	P	7
2006.9583	294.09	9.729						2	1	Pal	C		7
2006.9583	294.11	9.725						2	1	Nov	C		7
2010.5	293.6	10.10	10.71	0.02	9.122	0.02	335	0.4	1	WIS	Hw		7
2010.5		10.74			9.195	0.02	460	0.4	1	WIS	Hw		7
2010.5		10.83			9.149	0.03	11.	u 0.4	1	WIS	Hw		7
2010.5.		>9.14			>8.714		22.	u 0.4	1	WIS	Hw		7
2011.62	293.77	10.23			1.97			2	1	Rdv	C		7
2011.8245	q293.66	10.27			-0.12			2	2	Pal	C		7
2011.8437	q293.39	10.26			-0.38			0.6	1	Pal	C		7
2012.8574					-0.43	0.01	44	98 2	1	Cve	C		7
2012.8574	q293.55	10.36			-0.12	0.01	55	89 2	1	Cve	C		7

Values to which we can add those obtained with the catalog GAIA-DR1 and those which I measured on the images of 2017 with Astrometrica and Reduc softwares.

Epoch	theta	e_t	ρ	e_r	mA	e_m	mB	e_m	band	n	Observer
2015.0	292.83	0.001	0.719	0.0002	11.911	.	11.485	.	G	1	Gaia-DR1
2017.916	293.16	0.69	0.679	0.120	11.931	0.099	12.152	0.095	g'	1	DBR[1]
2017.916	292.83	1.21	0.719	0.083	11.895	0.021	11.622	0.051	r'	1	DBR[2]

1. Using Astrometrica-Makali'i
2. Using Reduc-Makali'i

These last measurements are in agreement with the previous ones and show a retrograde movement of about 40° in a little more than a century.

Measures with :	Residuals (O-C) θ (°)	ρ(″)
Astrometrica + Gaia DR1	+0.36	+0.620
Reduc	+0.03	+0.660

Discussion

The first calculated orbital elements give a period of 1360.2 years and periastron passage in year 3235.4. The Sixth Catalog of Visual Binary Orbits (6COBVS) ranks this orbit in category 5, i.e. "indeterminate". This study shows that it is probably premature to calculate an orbit, indeed, if one observes the displacement of the component B with respect to the component A from 1912 to 2017, one finds a linear trajectory compatible with the available observations. In the original publication of the orbit by Cvetkovic and Ninkovic[14], it is regrettable that the authors did not mention this hypothesis in the note concerning WDS07106+1543. There is also no note on this couple in the 6COBVS.

Acknowledgments

The author warmly thanks William Hartkopf for the historical data on the couple studied, David Chiron, Herbert Raab and Florent Losse, designers of the software Wdstool, Astrometrica and Reduc respectively, and the NAOJ (National Astronomical Observatory of Japan) which makes available Makali'i software. He especially thanks Daniel Bonneau, scientific advisor of the Commission of the Double Stars of the Astronomical Society of France for the review of this article and his judicious remarks, Pierre Durand, vice-president of the commission as well as André Amossé President of the Jonckheere Association and member of the commisssion.

This study made use of: The Washington Double Star Catalog maintained at the U.S. Naval Observatory. The VizieR catalogue access tool, CDS, Strasbourg, France. The original description of the VizieR service was published in A&AS 143, 23. Data from the European Space Agency (ESA) mission Gaia (`https://www.cosmos.esa.int/gaia`), processed by the Gaia Data Processing and Analysis Consortium (DPAC, `https://www.cosmos.esa.int/web/gaia/dpac/consortium`). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement. The fourth U.S. Naval Observatory CCD Astrograph Catalog (UCAC4) by Zacharias N., Finch C.T., Girard T.M., Henden A., Bartlet J.L., Monet D.G., Zacharias M.I. Data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation.

References

1). http://wdstool.com/index.php
2). www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/WDS
3). https://archive/loco/global/?q=a&RLEVEL=91&PROPID=&INSTRUMEN=kb80&OBJECT=J703&SITEID=elp&TELID=0m4a&FILTER=&OBSTYPE=&EXPTIME=&BLKUID=&REQNUM=&basename=&start=2017-11-28%2000:00&end=2017-02-02%2023:00&id=&public=true
4). http://www.astrometrica.at/
5). https://www.cosmos.esa.int/web/gaia
6). http:astrosurf.com/hfosaf/uk/tdownload.htmředuc
7). http://www.usno.navy.mil/USNO?astrometry/optical-IR-prod/ucac
8). https://www.ipac.caltech.edu/2mass/

9). http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/orb6
10). https://makalii.mtk.nao.ac.jp
11). https://www.aavso.org.apass
12). http://skyserver.sdss.org/dr1/en/proj/advanced/color/sdssfilters.asp
13). https://www.aavso.org/vsx/
14). Cvetkovic, Z. & Ninkovic, 2008, New Astronomy, **13**, 587

2017 MEASUREMENTS OF SOME WIDE AND FAINT DOUBLE STARS

Wilfried R.A. Knapp, Vienna, Austria

E-mail: wilfried.knapp@gmail.com

Abstract

This report presents astrometry and photometry results from images taken during the year 2017 for about 50 WDS objects considered to be in need of precise measurements for different reasons like for example questionable magnitude for the secondary or unexpected results in visual observing sessions.

Report

The given photometry and astrometry results for the listed objects in table 1 are based on image stacks taken with V-filter and in some cases also with I-filter to check a suspected color issue. WDS ID is the WDS catalog ID and Object gives the discoverer ID with components. RA and Dec are the coordinates based on plate solving with URAT1 (if available, else UCAC4) reference stars in the 8.5 to 18.5mag range. Sep is separation calculated as SQRT$(((\alpha_1-\alpha_2)*\cos(\delta_1))^2+(\delta_2-\delta_1)^2)$ in radians. PA is calculated as $\arctan((\alpha_2-\alpha_1)*\cos(\delta_1))/(\delta_2-\delta_1))$ in radians depending on quadrant. Mag is for V filter images the differential photometry V mag result based on URAT1 reference stars and for I filter images the differential photometry I mag result based on USNO B1 reference stars. Ap is the aperture used. Date is the Julian epoch. iT in the Notes column indicates the telescope used with type of filter, number of images and exposure time. WDS observation method code is in all cases "C".

Table 1: Astrometry and photometry results

WDS ID	Object	RA	Dec	Sep	PA	M_1	M_2	Spc1; Spc2	Ap	Date
17317+1111	AG 354 AB	262,9223	11,18135556	2.751	54.940	9.442	9.436		0.610	2017.495
iT24 5x3s V filter. Heavily overlapping star disks - stars too bright for resolution with the given equipment										
05119+0204	BAL 1286 AB	77,95430833	2,071888889	19.584	174.686	10.438	12.562		0.610	2017.045
iT24 5x3s V filter										
05134+0132	BAL 1287 AB	78,34984583	1,529777778	10.733	109.201	10.024	11.597		0.610	2017.045
iT24 5x3s V filter										
06461-0141	BAL 339 AB	101,51335	-1,685519444	7.724	224.804	8.307	12.002		0.318	2017.203
iT18 5x3s V filter. SNR B <20										
06462-0153	BAL 341 AB	101,5486708	-1,889686111	19.297	269.080	12.503	12.915		0.318	2017.203
iT18 5x3s V filter. SNR A and B <20										
06514-0033	BAL 728 AB	102,8429125	-0,556419444	12.016	214.608	11.933	12.653		0.318	2017.203

iT18 5x3s V filter. SNR B <20										
10085+1206	BRT 1267 AB	152,12245	12,10695833	3.770	0.446	10.541	12.560		0.610	2017.365
iT24 3x1s V filter										
05463+2542	BRT 138 AB	86,56845417	25,70163889	5.958	119.678	8.210	11.663		0.610	2017.045
iT 24 5x3s V filter. Overlapping star disks										
20388+4629	BRT 2268 AB	309,7051875	46,49421944	3.292	313.830	11.124	12.350		0.318	2017.641
iT18 5x3s V filter. SNR B <20										
	BRT 2268 AB	309,7052167	46,49420278	3.284	317.466	11.094	12.467		0.610	2017.691
iT24 5x3s V filter. Touching star disks										
	BRT 2268 AB	309,7052792	46,49414167	3.437	320.439	10.104	12.340	K2-K5; A3-F2	0.610	2017.705
iT24 5x3s I filter. Touching/overlapping star disks. Spc estimated from $V-I$ color index: Primary reddish, secondary white										
12553-0336	BRT 442 AB	193,8186792	-3,607947222	8.061	201.690	9.779	11.013		0.610	2017.365
iT24 4x1s V filter										
19385+1715	BU 1471 AB	294,6145375	17,25721944	12.496	332.559	7.479	12.275		0.318	2017.578
iT18 5x2s V filter. SNR B <20										
07332+3252	BU 22 AB	113,3115	32,8619	6.321	151.029	8.214	10.941		0.318	2017.242
iT18 5x1s V filter. SNR B <20										
06508-0032	BU 897 AB	102,7077167	-0,541766667	6.589	24.191	5.750	11.053		0.318	2017.222
iT18 5x2s V filter. Overlapping star disks. SNR B <20										
	BU 897 AB	102,7077292	-0,541769444	6.421	23.250	5.747	11.295		0.318	2017.203
iT18 5x3s V filter. Overlapping star disks. SNR B <20										
	BU 897 AB	102,7077458	-0,541769444	6.707	24.157	5.756	11.160		0.318	2017.222
iT18 3x3s V filter. Overlapping star disks										
	BU 897 AB	102,707775	-0,541786111	6.370	23.304	5.766	11.561		0.318	2017.222
iT18 5x1s V filter. Overlapping star disks. SNR B <10										
11098+6123	ES 1906 AB	167,4517792	61,40401111	4.540	278.742	10.986	12.596	K0-K4; K1-K5	0.610	2017.327
iT24 5x1s I filter. Spc according to $V-I$ color index: Both components orange										
	ES 1906 AB	167,451825	61,40397778	4.857	279.601	11.844	13.574		0.610	2017.327
iT24 5x1s V filter										
20286+5039	HJ 1524 AB	307,148725	50,65021389	5.279	126.362	9.206	10.731		0.318	2017.578
iT18 5x1s V filter										
20396+1555	HJ 1554 AC	309,9098792	15,91200556	48.363	277.497	3.827	11.898		0.318	2017.578
iT18 4x2s V filter										
13569+5354	HJ 2694 AB	209,2174583	53,89413889	43.000	83.148	7.864	11.742		0.610	2017.305
iT24 1x3s V filter										
10147+1648	HJ 4296 AB	153,6679625	16,76910833	15.884	142.908	9.308	11.885		0.610	2017.365
iT24 5x1s V filter										
	HJ 4296 AB	153,6679958	16,76905	15.635	141.880	9.328	11.943		0.610	2017.081
iT24 5x3s V filter										
10120+2007	HJ 476 AB	153,012625	20,11850556	24.038	48.844	7.484	12.168		0.610	2017.081
iT24 5x3s V filter										

05397+2700	HJ 705 AB	84,93040	27,14140278	16.070	287.044	10.837	12.410		0.610	2017.078
iT24 5x3s V filter										
05397+2700	HJ 705 BC	84,92560417	27,14271111	20.173	347.310	12.410	14.290		0.610	2017.078
iT24 5x3s V filter										
05428+2652	HJ 707 AB	85,70505833	26,8765	11.140	193.971	10.995	12.228		0.610	2017.078
iT24 5x3s V filter										
05512+2817	HJ 711 AB	87,79200	28,27538889	16.872	354.699	10.431	11.939		0.610	2017.078
iT24 5x3s V filter										
05498+0605	HJ 712 AB	87,44478333	6,090088889	9.366	82.824	9.768	10.895	A3-F2; A0-F2	0.610	2017.946
iT24 1x3s I filter. Spc estimated by $V-I$ color index: Both components blue-white										
	HJ 712 AB	87,44504583	6,090069444	9.311	84.144	9.889	10.974		0.610	2017.946
iT24 5x3s V filter										
20367+5053	HLD 39 AB	309,1791625	50,88978333	7.469	174.111	7.871	11.338		0.610	2017.388
iT24 5x1s V filter										
	HLD 39 AB	309,1791667	50,88976389	7.466	174.399	7.871	11.389		0.318	2017.578
iT18 3x2s V filter										
19045+3406	J 1209 AB	286,1045167	34,10546111	4.443	154.500	11.520	12.274		0.610	2017.495
iT24 5x3s V filter										
21046+3116	J 2336 AB	316,1367125	31,26178889	9.081	39.868	11.663	12.053		0.318	2017.578
iT18 5x3s V filter										
05386+0654	J 2730 AB	84,65326667	6,884708333	5.174	212.368	11.424	12.864		0.610	2017.045
iT24 5x3s V filter										
21050+3109	J 3124 AB	316,1475125	31,10448889	4.538	27.653	11.011	13.034		0.318	2017.578
iT18 4x3s V filter. Position A/B reversed. SNR CB <20										
20534+1921	J 573 AB	313,3272042	19,37505278	4.076	182.985	11.745	12.826		0.610	2017.388
iT24 5x1s V filter										
	J 573 AB	313,3272042	19,37506111	4.186	186.405	11.652	12.424	A2-F2; F2-K0	0.610	2017.719
iT24 5x3s I filter. Touching star disks. Spc estimated from $V-I$ color index - primary white, secondary yellow										
	J 573 AB	313,3272167	19,37505	4.107	185.140	11.762	12.938		0.610	2017.549
iT24 5x3s V filter										
05355+0723	J 676 AB	83,88251667	7,388358333	1.849	300.565	9.878	9.666		0.610	2017.045
iT24 5x3s V filter. Overlapping star disks										
07240+3427	POP 74 AB	111,0410167	34,45816111	9.550	148.015	11.003	12.162		0.318	2017.242
iT18 2x3s V filter. SNR B <20										
	POP 74 AB	111,0410542	34,45821944	9.785	148.021	10.949	12.153		0.610	2017.365
iT24 5x1s V filter										
20208+3748	SEI 1095 AB	305,2098333	37,80214444	24.685	62.652	11.610	12.088		0.318	2017.578
iT18 5x3s V filter										
07346+3153	STF 1110 AB	113,6483625	31,88754444	5.200	51.603	2.335	2.940		0.318	2017.242
iT18 4x1s V filter. Heavily overlapping star disks. Star disk for A saturated										
	STF 1110 AC	113,6483625	31,88754444	69.773	163.444	2.335	9.090		0.318	2017.242

iT18 4x1s V filter. Star disk for A saturated										
	STF 1110 AD	113,6483625	31,88754444	179.817	221.169	2.335	9.976		0.318	2017.242
iT18 4x1s V filter. Star disk for A saturated										
17287+1029	STF 2170 AB	262,182025	10,48376667	3.309	57.870	9.188	9.733		0.610	2017.495
iT24 5x3s V filter										
19168+6742	STF 2514 AB	289,2128583	67,692575	23.183	350.572	9.516	11.332		0.610	2017.388
iT24 5x1s V filter										
19450+4508	STF 2579 AC	296,2437917	45,13096944	62.533	67.163	0.000	12.277		0.610	2017.495
iT24 5x3s V filter. A far too bright for reliable photometry										
19523+1021	STF 2590 AB	298,0649208	10,35153611	13.575	308.497	6.427	10.520		0.318	2017.578
iT18 2x1s V filter										
20244+1935	STF 2679 AB	306,0940458	19,5749	24.424	77.323	7.823	9.760		0.318	2017.578
iT18 5x1s V filter										
	STF 2679 AB	306,0940667	19,57491111	24.394	77.331	7.832	9.744		0.318	2017.578
iT18 5x1s V filter										
	STF 2679 AC	306,0940667	19,57491111	38.596	149.866	7.832	11.502		0.318	2017.578
iT18 5x1s V filter. SNR C <20										
22453-0939	STF 2939 AB	341,3367667	-9,644591667	11.182	60.479	7.401	10.492		0.610	2017.730
iT24 5x1s V filter. GAIA DR1 plate solved for coordinates and UCAC4 for V-magnitudes										
	STF 2939 AB	341,3367875	-9,644625	11.006	62.806	7.160	9.681	A6-G0; G8-K4	0.610	2017.733
iT24 5x1s I filter. Spc according to $V-I$ color index: White for A and yellow-orange for B										
22477-1403	STF 2943 AB	341,9283833	-14,05653333	20.782	127.044	5.695	9.662		0.610	2017.730
iT24 5x1s V filter. GAIA DR1 plate solved for coordinates and UCAC4 for V-magnitudes										
	STF 2943 AB	341,9284042	-14,05644444	21.014	127.354	6.136	9.457	B8; A5-F8	0.610	2017.730
iT24 5x1s V filter. Spc estimated by V-I color index: A blueish and B white										
03474+2355	STF 450 AB	56,85178333	23,91445278	5.783	263.447	7.240	9.358	A2-F2; G2-K3	0.610	2017.039
iT24 10x3s I filter. Touching star disks. Spc according to $V-I$ color index: Blue-white for A and reddish-yellow for B										
	STF 450 AB	56,8518125	23,91443889	6.273	262.949	7.373	10.040		0.610	2017.039
iT24 10x3s V filter. Touching star disks										
07344+3307	STT 173 AC	113,6028208	33,12241111	18.699	233.662	7.803	12.102		0.318	2017.242
iT18 5x3s V filter. SNR C <20										
15348+2500	STT 297 AB	233,7063083	24,99858333	12.829	331.932	8.259	12.005		0.610	2017.495
iT24 5x3s V filter. Image quality a bit questionable										
16530+4424	STT 317 AB	253,2383167	44,40275	24.985	199.989	8.050	12.477		0.610	2017.495
iT24 5x3s V filter										
21395+4144	STT 447 AC	324,8696875	41,72666389	14.036	176.479	7.529	11.184		0.318	2017.578
iT18 5x1s V filter. SNR C <20										
03334+2322	STT 57 CD	53,36050	23,38415	10.049	320.731	6.135	10.385	K5-K7; K3-K5	0.610	2017.946
iT24 5x3s I filter. Spc estimated by $V-I$ color index (V mag from earlier measurement): Both components orange										

The measurement errors for the results in Table 1 are given as follows: dRA and dDec are the average RA and Dec plate solving errors. e_Sep is the error estimation for Sep calculated as SQRT($\Delta\alpha^2$+$\Delta\rho^2$). e_PA is the error estimation for PA calculated as arctan(ϵ_ρ/ρ) in degrees assuming the worst case that e_Sep points in the right angle to the direction of the separation means perpendicular to the separation vector. e_Mag1/2 is the error estimation for Mag1/2 and calculated as SQRT(ΔV^2 + (2.5*Log10(1+1/SNR))^2) with dmag as the average magnitude error over all used reference stars and SNR is the signal to noise ratio for the star disks of the measured components.

Table 2: Measurement errors

Object	dRA	dDec	e_Sep	e_PA	e_Mag1	e_Mag2	dmag	SNR1	SNR2
AG 354 AB	0.09	0.10	0.135	2.800	0.080	0.081	0.08	122.76	112.11
BAL 1286 AB	0.12	0.10	0.156	0.457	0.091	0.092	0.09	103.93	52.50
BAL 1287 AB	0.12	0.11	0.163	0.869	0.081	0.081	0.08	116.53	75.00
BAL 339 AB	0.09	0.07	0.114	0.846	0.080	0.098	0.08	123.1	18.55
BAL 341 AB	0.09	0.07	0.114	0.339	0.104	0.109	0.08	15.76	14.07
BAL 728 AB	0.08	0.07	0.106	0.507	0.100	0.109	0.09	24.62	17.06
BRT 1267 AB	0.12	0.11	0.163	2.472	0.071	0.077	0.07	100.45	33.70
BRT 138 AB	0.10	0.09	0.135	1.294	0.060	0.068	0.06	244.19	34.28
BRT 2268 AB	0.08	0.08	0.113	1.968	0.106	0.127	0.10	30.88	13.25
BRT 2268 AB	0.07	0.07	0.099	1.727	0.070	0.073	0.07	138.98	53.98
BRT 2268 AB	0.10	0.12	0.156	2.602	0.130	0.135	0.13	113.89	30.63
BRT 442 AB	0.07	0.07	0.099	0.704	0.060	0.061	0.06	150.26	86.34
BU 1471 AB	0.06	0.07	0.092	0.423	0.090	0.109	0.09	168.57	17.06
BU 22 AB	0.11	0.13	0.170	1.543	0.091	0.110	0.09	71.94	16.54
BU 897 AB	0.08	0.07	0.106	0.948	0.090	0.106	0.09	326.75	18.80
BU 897 AB	0.09	0.07	0.114	0.974	0.090	0.104	0.09	338.38	20.67
BU 897 AB	0.09	0.07	0.114	0.991	0.090	0.106	0.09	286.73	19.18
BU 897 AB	0.11	0.05	0.121	1.087	0.100	0.173	0.10	127.61	7.23
ES 1906 AB	0.07	0.11	0.130	1.538	0.062	0.080	0.06	64.21	20.16
ES 1906 AB	0.10	0.10	0.141	1.784	0.142	0.149	0.14	50.41	21.14
HJ 1524 AB	0.08	0.07	0.106	1.154	0.112	0.119	0.11	51.25	24.10
HJ 1554 AC	0.07	0.06	0.092	0.109	0.080	0.095	0.08	513.31	20.47
HJ 2694 AB	0.12	0.08	0.144	0.192	0.080	0.081	0.08	380.26	92.32
HJ 4296 AB	0.15	0.1	0.180	0.661	0.080	0.081	0.08	190.00	72.94
HJ 4296 AB	0.06	0.11	0.125	0.452	0.060	0.061	0.06	212.08	83.29
HJ 476 AB	0.14	0.07	0.157	0.373	0.080	0.084	0.08	178.76	39.58
HJ 705 AB	0.10	0.11	0.149	0.530	0.071	0.072	0.07	124.25	67.04
HJ 705 BC	0.10	0.11	0.149	0.422	0.016	0.080	0.07	67.04	27.45
HJ 707 AB	0.09	0.10	0.135	0.692	0.008	0.071	0.07	129.25	76.04
HJ 711 AB	0.09	0.10	0.135	0.457	0.009	0.062	0.06	119.43	79.00
HJ 712 AB	0.11	0.09	0.142	0.875	0.090	0.091	0.09	125.89	84.09

HJ 712 AB	0.12	0.09	0.150	0.918	0.111	0.111	0.11	100.42	72.85
HLD 39 AB	0.10	0.10	0.141	1.085	0.070	0.076	0.07	146.78	36.33
HLD 39 AB	0.06	0.07	0.092	0.708	0.090	0.101	0.09	137.74	23.15
J 1209 AB	0.07	0.07	0.099	1.276	0.081	0.082	0.08	92.53	55.50
J 2336 AB	0.09	0.09	0.127	0.803	0.097	0.100	0.09	29.65	23.99
J 2730 AB	0.11	0.12	0.163	1.802	0.082	0.085	0.08	60.19	39.17
J 3124 AB	0.07	0.07	0.099	1.250	0.094	0.132	0.09	39.25	10.81
J 573 AB	0.11	0.11	0.156	2.186	0.073	0.081	0.07	50.55	26.24
J 573 AB	0.09	0.08	0.120	1.648	0.121	0.124	0.12	70.03	36.62
J 676 AB	0.12	0.11	0.163	5.033	0.093	0.095	0.09	46.10	35.38
POP 74 AB	0.10	0.12	0.156	0.937	0.105	0.116	0.10	34.44	17.94
POP 74 AB	0.09	0.11	0.142	0.832	0.071	0.074	0.07	75.80	45.13
SEI 1095 AB	0.06	0.07	0.092	0.214	0.087	0.094	0.08	30.53	21.75
STF 1110 AB	0.13	0.13	0.184	2.025	0.090	0.090	0.09	248.24	253.01
STF 1110 AC	0.13	0.13	0.184	0.151	0.090	0.093	0.09	248.24	48.86
STF 1110 AD	0.13	0.13	0.184	0.059	0.090	0.096	0.09	248.24	31.88
STF 2170 AB	0.08	0.09	0.120	2.084	0.081	0.082	0.08	88.54	68.84
STF 2514 AB	0.13	0.09	0.158	0.391	0.081	0.082	0.08	92.90	53.44
STF 2579 AC	0.07	0.08	0.106	0.097		0.081	0.08		89.34
STF 2590 AB	0.09	0.10	0.135	0.568	0.090	0.100	0.09	185.57	24.23
STF 2679 AB	0.11	0.09	0.142	0.333	0.091	0.094	0.09	104.19	41.95
STF 2679 AB	0.08	0.07	0.106	0.250	0.081	0.084	0.08	103.56	41.10
STF 2679 AC	0.08	0.07	0.106	0.158	0.081	0.100	0.08	103.56	17.61
STF 2939 AB	0.10	0.11	0.149	0.762	0.070	0.071	0.07	294.19	105.18
STF 2939 AB	0.10	0.10	0.141	0.736	0.100	0.100	0.10	217.56	133.86
STF 2943 AB	0.15	0.09	0.175	0.482	0.090	0.090	0.09	324.28	151.31
STF 2943 AB	0.10	0.09	0.135	0.367	0.070	0.071	0.07	176.33	108.81
STF 450 AB	0.11	0.09	0.142	1.298	0.080	0.084	0.08	157.60	40.73
STF 450 AB	0.11	0.11	0.156	1.541	0.174	0.258	0.13	64.25	17.22
STT 173 AC	0.06	0.13	0.143	0.439	0.080	0.097	0.08	141.15	19.18
STT 297 AB	0.10	0.11	0.149	0.664	0.091	0.092	0.09	108.04	52.97
STT 317 AB	0.07	0.09	0.114	0.261	0.070	0.072	0.07	244.85	70.83
STT 447 AC	0.05	0.05	0.071	0.289	0.090	0.106	0.09	115.48	18.58
STT 57 CD	0.10	0.10	0.141	0.806	0.120	0.122	0.12	138.81	49.71

Finally all objects are checked for potential physical relationship by means of common proper motion using either UCAC5 proper motion data if given with a sufficient small error range or else by comparing 2MASS with GAIA DR1 positions if for both components available. The given RA/Dec coordinates are from GAIA DR1, Sep and PA are calculated from the GAIA DR1 positions for both components. The given proper motion data are either directly from UCAC5 or calculated from the difference between 2MASS and GAIA DR1 positions. CPM

Rat is the letter based CPM rating (according to Knapp/Nanson 2016 with extensions) for proper motion vector direction, proper motion vector length, relationship of vector length of proper motion error to proper motion and relationship of angular separation to proper motion speed. CPM Score translates the letter based rating into an estimated probability for being physical. Source/Notes gives the used sources with additional comments. GAIA aperture is rectangular equivalent to a circular surface of 0.96m radius, observation epoch is 2015.0 and observation method code is Hg.

Table 3: CPM Check

Object	RA	Dec	Sep	PA	μ_{α_1}	μ_{δ_1}	e_{pm1}	μ_{α_2}	μ_{δ_2}	e_{pm2}	CPM Rating	CPM Score
AG 354 AB	262.92229940	11.1815717	2.463	51.719	54.50	2.00	18.91	57.70	3.40	15.38	ABDA	52
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Undecidable, e_{pm} data too large												
BAL 1286 AB	77.95441330	2.0718897	19.538	174.882	0.10	1.20	5.81	1.50	1.20	16.24	DDDD	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
BAL 1287 AB	78.34989920	1.5298075	10.609	110.082	19.00	2.20	7.72	0.40	1.40	3.77	DDDC	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
BAL 339 AB	101.51330889	-1.6855070	7.655	223.395	13.42	-38.58	7.27	-12.70	-26.28	7.27	CCCB	6
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. Almost certainly optical												
BAL 341 AB	101.54865560	-1.8896892	19.256	269.078	-2.60	1.20	2.95	-2.50	1.20	1.22	AADC	62
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Potentially physical but pm values too small to be significant												
BAL 728 AB	102.84292080	-0.5564033	12.104	214.240	-0.60	1.20	9.18	-2.80	1.20	2.16	DDDC	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
BRT 1267 AB	152.12244360	12.1069953	3.960	1.416	50	1.20	6.00	3.00	3.20	7.76	DDDC	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
BRT 138 AB	86.56840420	25.7016367	6.073	119.030	4.80	2.60	8.51	-3.10	6.00	11.07	DDDB	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
BRT 2268 AB	309.70523330	46.4941800	3.363	317.557	-2.00	1.30	4.97	-1.70	1.70	3.80	DADC	1
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
BRT 442 AB	193.81870291	-3.6079164	8.035	201.579	-30.18	-39.09	9.62	-37.85	-41.93	9.62	BCCB	25
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. Most probably optical												
BU 1471 AB	294.61450750	17.2572053	12.467	332.502	2.50	2.20	26.49	-0.50	2.00	9.41	DDDC	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
BU 22 AB	113.31155470	32.8618511	6.395	151.137	-20.00	1.50	5.22	-19.80	5.20	6.22	DADB	1
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
BU 897 AB	102.70771485	-0.5416558	6.565	21.131	15.75	-194.18	7.06	11.55	-176.00	6.13	ABAA	80
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. Most probably physical												
ES 1906 AB	167.45181470	61.4040136	4.653	276.937	5.70	1.30	2.14	6.90	1.50	1.61	ADDB	3
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
HJ 1524 AB	307.14870407	50.6502559	5.297	125.339	16.66	-76.11	6.29	21.67	-73.44	6.29	BABB	74
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. Probably physical												

HJ 1554 AC		? ?	?	?	?	?	?	?	?	?	?	?
No GAIA DR1 object for the primary												
HJ 2694 AB	209.21757670	53.8940714	42.888	83.334	-36.60	2.10	2.70	-9.40	1.20	9.38	BDCC	3
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
HJ 4296 AB	153.66793426	16.7690466	15.528	142.363	32.14	-24.53	4.97	38.00	-28.50	4.97	ACCC	30
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. Probably optical												
HJ 476 AB	153.01256327	20.1185062	24.171	48.970	31.40	-21.65	7.52	36.21	-12.15	6.28	CACC	15
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Most probably optical												
HJ 705 AB	84.93044580	27.1413356	16.138	287.288	4.20	1.10	8.77	1.60	1.10	6.49	DDDC	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
HJ 705 BC	84.92563575	27.1426679	20.373	347.117	-0.99	-5.52	4.98	-3.78	4.55	4.98	CBCC	12
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. Most probably optical												
HJ 707 AB	85.70506140	26.8764858	11.099	193.715	2.10	1.00	7.57	4.00	1.00	4.41	DDDC	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
HJ 711 AB	87.79198110	28.2754117	16.699	354.778	-26.59	-52.66	4.98	-1.73	-8.41	4.98	CCCB	6
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. Almost certainly optical												
HJ 712 AB	87.44502280	6.0900917	9.083	83.546	2.60	1.10	2.11	2.90	1.10	2.02	ABDC	49
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Undecidable												
HLD 39 AB	309.17913190	50.8897667	7.535	174.344	-1.70	2.40	8.64	6.70	3.80	5.88	DDDC	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
J 1209 AB	286.10450060	34.1054811	4.552	154.653	3.20	1.30	7.02	0.30	1.30	3.64	DDDC	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
J 2336 AB	316.13674310	31.2617956	9.075	39.707	-2.80	1.10	10.96	0.70	1.10	2.20	DDDC	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
J 2730 AB	84.65324330	6.8851322	5.223	209.107	5.00	1.20	7.10	-21.60	1.60	13.99	DDDB	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
J 3124 AB	316.14752500	31.1045072	4.680	25.881	0.50	1.20	22.03	1.30	2.30	17.85	CDDC	1
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
J 573 AB	313.32722030	19.3750417	4.145	185.289	4.20	1.20	2.51	3.20	1.30	3.00	CDDC	1
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
J 676 AB		? ?	?	?	?	?	?	?	?	?	?	?
Neither UCAC5 nor 2MASS object for the secondary												
POP 74 AB	111.04108110	34.4581800	9.489	147.989	8.90	1.10	7.48	-0.20	1.10	4.54	DDDC	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
SEI 1095 AB	305.20984280	37.8021325	24.670	62.736	-3.40	1.30	4.49	-4.10	1.30	5.17	BDDC	2
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
STF 1110 AB	?	?	?	?	?	?	?	?	?	?	?	?
No GAIA DR1 object for both components												
STF 1110 AC	?	?	?	?	?	?	?	?	?	?	?	?
No GAIA DR1 object for the primary												
STF 1110 AD	?	?	?	?	?	?	?	?	?	?	?	?

No GAIA DR1 object for the primary												
STF 2170 AB	262.18198512	10.4838378	3.386	58.215	24.29	-113.99	1.16	17.80	-111.91	1.19	CBAA	
GAIA DR1. PM data from GAIA DR1 catalog. Change of Sep and PA over time obviously due to high speed proper motion - potential orbit?												
STF 2514 AB	289.21270107	67.6925499	23.307	351.168	0.80	-28.46	5.92	23.44	92.56	5.92	CCCB	6
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. Almost certainly optical												
STF 2579 AC	?	?	?	?	?	?	?	?	?	?	?	?
No GAIA DR1 object for the primary												
STF 2590 AB	298.06491400	10.3515398	13.591	308.676	8.34	-9.53	6.39	-1.43	-19.17	5.58	CCCC	6
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. Almost certainly optical												
STF 2679 AB	?	?	?	?	?	?	?	?	?	?	?	?
No GAIA DR1 object for the primary												
STF 2679 AC	?	?	?	?	?	?	?	?	?	?	?	?
No GAIA DR1 object for the primary												
STF 2939 AB	341.33675625	-9.6445834	11.030	61.153	33.51	-6.56	7.72	38.81	-2.10	7.72	CCCB	6
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. Almost certainly optical												
STF 2943 AB	?	?	?	?	?	?	?	?	?	?	?	?
No GAIA DR1 object for the primary												
STF 450 AB	56.85181539	23.9144902	6.273	263.199	26.52	-46.70	5.82	24.84	-49.50	5.82	BACB	62
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. CPM rating not perfect, but probably physical												
As Vmag B has to be fainter than G mag B, the given G mag data rather confirms own V mag measurement and not current WDS data												
STT 173 AC	113.60283768	33.1224490	18.806	233.506	-12.42	-18.57	5.27	-7.63	-28.37	5.27	CCCB	6
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. Almost certainly optical												
STT 297 AB	233.70623320	24.9986267	12.635	332.470	66.43	-117.60	5.94	-12.55	10.90	5.94	CCCB	6
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. Almost certainly optical												
STT 317 AB	253.23833061	44.4026826	24.796	200.420	-18.06	66.16	5.12	8.06	-12.68	5.12	CCCC	6
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. Almost certainly optical												
STT 447 AC	324.86969610	41.7266722	14.062	176.416	10.00	2.90	6.84	2.50	3.20	3.77	DDDC	0
GAIA DR1. M1 and M2 are *G*-band. PM data from UCAC5. Almost certainly optical												
STT 57 CD	53.36052151	23.3842112	9.953	319.896	-6.06	-33.07	14.02	-8.80	-33.16	14.02	BACB	62
GAIA DR1. M1 and M2 are *G*-band. PM data calculated from position comparison with 2MASS. PM values suggest common proper motion but due to the large e_{pm} value undecidable												

With few exceptions all of the checked WDS objects are to be considered as optical pairs.

References

Buchheim, Robert, 2008, CCD Double-Star Measurements at Altimira Observatory in 2007, *Journal of Double Star Observations*, **4** No. 1, 28.
Knapp, Wilfried R.A. and Nanson, John, 2017, A new concept for counter-checking of assumed CPM pairs, *Journal of Double Star Observations*, **13**, No. 1, 31.

Acknowledgements

The following tools and resources have been used for this research:
Washington Double Star Catalog
iTelescope:
iT24 0.61m: 610mm CDK with 3962mm focal length. CCD: FLI-PL09000. Resolution 0.62 arcsec/pixel. *V* filter. Located in Auberry, California. Elevation 1405m
iT18 0.31m: 318mm CDK with 2541mm focal length. CCD: SBIG-STXL-6303E. Resolution 0.73 arcsec/pixel. *V* filter. Located in Nerpio, Spain. Elevation 1650m
2MASS All Sky Catalog
URAT1 Catalog
UCAC4 Catalog
GAIA DR1 Catalog
AAVSO VPhot
Aladin Sky Atlas v9.0
SIMBAD, VizieR
AstroPlanner v2.2
MaxIm DL6 v6.08
Astrometrica v4.10.0.427
Special thanks to Robert Korn for indicating STF 2943 and STF 2939 being in need of new photometry

Index of previous Circulars

DSSC1: Measurements of 232 double stars by five observers between 1971 and 1979 (Double Star Section). Pp.18, 1979

DSSC2: Measures of the 7th hour of RA of Pourteau's Carte du Ciel double stars from POSS (D. Gellera) Pp.26, 1982

DSSC3: Measures of the 18th hour of RA of Pourteau's Carte du Ciel double stars from POSS (D. Gellera)
Micrometric measurements of double stars 1975.0 - 1983.0 (Double Star Section)
A colour catalogue of double and multiple stars based on human colour perception (J. J. Kaznica *et al.*) Pp.55, 1984

DSSC4: Photographic measures of 50 white dwarf pairs discovered by Luyten from POSS plates (D. Gellera)
Micrometric measurements of double stars 1983.0 - 1988.0 (Double Star Section) Pp.35, 1989

DSSC5: Micrometric measurements of double stars 1988.0 - 1992.0 (Double Star Section) Pp.47, 1992

DSSC6: Micrometric measurements of double stars 1992.0 - 1995.0 (Double Star Section)
Photographic measurements of 383 double stars of Pourteau's Catalogue (D. Gellera)
Pp.101, 1996

DSSC7: Micrometric measurements of double stars 1995.0 - 1998.0 (Double Star Section)
Catalogue of measurements of 182 double stars made with a CCD camera and 40-cm SCT (G. A. Elliott) Pp.43, 1998

DSSC8: Micrometric measurements of double stars 1998.0 - 2000.0 (Double Star Section) Pp.23, 2000

DSSC9: Micrometric measures of double stars from 2000.0 - 2001.0 (Double Star Section)
Measures of 10 double stars made with a CCD camera and 20-cm Schmidt-Cassegrain telescope (J. D. West)
Σ889 : an optical double star (F. Rica Romero)
The PPM and HIPPARCOS Catalogues from a double star observer's point of view (J.−F. Courtot)
Pp.37, 2001

DSSC10: Micrometric measures of double stars from 2001.0 - 2002.0 (R. W. Argyle & J.-F. Courtot)
The nature of the double star Σ2259 (Francisco M. Rica Romero)
Measures of double stars with a CCD camera and 35.5-cm Newtonian telescope in 2001 (T. Ladányi & E. Berkó)
Recent measures of double stars made with a CCD camera (J. Doug West & M. Gallo)
Measures of double stars using eyepiece micrometers (M. Tollefsen & E. T. H. Teague)
Pp.47, 2002

DSSC11: Micrometric measures of double stars from 2002.0 - 2003.0 (R. W. Argyle & J.−F. Courtot)
Micrometric measures of double stars from 1998.02 to 2002.92 (A. Alzner)
An astrometric survey of 250 double stars - Paper I (M. Nicholson)
An astrometric survey of 250 double stars - Paper II (M. Nicholson)
An astrometric survey of 142 double stars - Paper III (M. Nicholson)
An astrometric survey of 187 double stars - Paper IV (M. Nicholson)
New double stars from the Daventry Double Star Survey (M. Nicholson)
Possible quadrant reversals in the Catalog 2001. 0 (R. Harshaw)
CCD measues of double stars 2002 (J. D. West)
Measures of double stars made with an eyepiece micrometer (M. Tollefsen)
A new component in the pair CHE 138 (T. Ladányi)
Measures of double stars with a CCD camera and 35.5-cm Newtonian telescope in 2002 (Ernő Berkó, Tamás Ladányi, and György Vaskúti)
Pp. 94, 2003

DSSC12: Micrometric measures of double stars from 2003.0 to 2004.0 (J.- F. Courtot & R. W. Argyle)
Measures of double stars made with an eyepiece micrometer (Magne Tollefsen)
Measures of double stars made with an eyepiece micrometer (Tim Leese)
CCD measures of double stars 2003 (Doug West)
Measures of double stars with a CCD camera and 35.5-cm reflector from 2002.953 to 2003.394 (Ernő Berkó, Tamás Ladányi, and György Vaskúti)
Data mining the Two Micron All Sky Survey 2MASS) for double stars (Martin Nicholson)
777 double stars in the Two Micron All Sky Survey (2MASS) (Martin Nicholson)
On double identities, recovered pairs, and optical imposters – investigations into some neglected double stars of the Washington Double Star Catalog (Richard Harshaw)
New measures for some neglected double stars of the Washington Double Star Catalog (Richard Harshaw)
Measures of some neglected southern double stars using the superCOSMOS database (Richard Jaworski)
Pp. 96, 2004

DSSC13: Micrometric measures of double stars from 2004.0 to 2005.0 (Bob Argyle)
Micrometer measurements from 2002.97 to 2004.94 (Andreas Alzner)
Measures of double stars with a CCD camera and 35.5-cm reflector from 2003.934 to 2003.942 (Ernő Berkó, Tamás Ladányi, and György Vaskúti)
Measures of neglected John Herschel southern double stars using on-line databases (Richard Jaworski)
Measures of selected John Herschel pairs between RA 0 h and 6 h using the SuperCOSMOS database (Richard Jaworski)
Suggested additional double stars to the WDS Catalog (Richard Jaworski)
The John Herschel multiple stars HJ 2116, HJ201 and HJ202 (Richard Jaworski)
Measures of neglected John Herschel southern double stars using the SuperCOSMOS database (Richard Jaworski)
Measures of 396 neglected southern double stars (Tòfol Tobal)
Possible anonymous southern visual double stars (Tòfol Tobal)
Measures of 622 neglected northern double star RA 00h - 12h 55m (Tòfol Tobal)
Measures of double stars made with an eyepiece micrometer (Magne Tollefsen)
Common proper motion pairs from the Sloan Digital Sky Survey (John Greaves)
HJ 327AC, HJ 2002 & HJ 9001 (Richard Jaworski and Bob Argyle)
Possible additional components to WDS double stars (Richard Jaworski)
A search for 'missing' Luyten double stars (Richard Jaworski)
Pp. 88, 2005

DSSC14: Micrometric measures of double stars from 2005.0 to 2006.0 (Bob Argyle)
Micrometer measures from 2004.94 to 2005.96 (Andreas Alzner)
Measures of double stars made with an eyepiece micrometer (Tim Leese)
2520 previously unreported double stars (Martin Nicholson & Hannah Varley)
Updated measures of neglected pairs in the Washington Double Star Catalog (Richard Harshaw)
BKO161 in place of STI 1445 (Gyorgy Vaskúti & Tamás Ladányi)
CCD measures of double stars at Palmer Divide Observatory - 2006.112 to 2006.238 (Brian D. Warner)
A modified industrial micrometer project - preliminary report (Morgan Spangle)
Some recent measures using a CCD camera (Morgan Spangle)
A search for 'missing' Luyten double stars - II (Richard Jaworski)
Measures of Luyten double stars using data from the 2MASS survey and SUPERCOSMOS image database (Richard Jaworski)
Measurement of the positions of Milburn (MLB) pairs from Sky Surveys (Richard Jaworski)
Measures of the neglected double star HJ2302 AB using the chronometric method (Ian Coster)
Pp. 68, 2006

DSSC15: Micrometric measures of double stars from 2006.0 to 2007.0 (Bob Argyle)
Measures of double stars with a CCD camera and 25-cm Cassgrain reflector in 2006 (Tamás Ladányi)
CCD observations of double stars at Waverley Observatory (Andrew Soon)
An analysis of errors in the measurement of visual double stars using the Celestron Micro-Guide with an SCT and Alt-Azimuth mount (Tim Napier-Munn)
Measures of 1027 neglected northern double stars RA 13h - 24h (Tòfol Tobal)
Measurement of the positions of Milburn (MLB) pairs from Sky Surveys - II (Richard Jaworski)
Some measures of double stars using the chronometric method, an eyepiece micrometer and the Aladin database (Ian Coster)
Candidate binary star systems in the Sloan Digital Sky Survey Data Release Five (Martin Nicholson)
Pp. 70, 2007

DSSC16: Micrometric measures of double stars in 2007 (Bob Argyle)
Micrometer measurements from 2006.21 to 2008.12 (Andreas Alzner)
Micrometric measures of double stars in 2007 (Jean - François Courtot)
Measures of double stars with a DSLR camera and 35.5-cm reflector from 2007.109 to 2007.194 (Ernő Berkó & György Vaskúti)
SDSS Data Release 6 proper motion information (John Greaves)
A trapezium in the field of Chevalier 138 (Thom Gandet)
Measurements of Selected Southern Double Stars - 1 (Richard Jaworski)
Measures of 1024 neglected visual double stars (Tòfol Tobal & Xavier Miret)
Pp. 84, 2008

DSSC17: Micrometric measures of double stars in 2008 (Bob Argyle)
Micrometer measures of the multiple system ES 1089 (Jean-François Courtot)
Measurement of some neglected southern multiple stars in Pavo (Tim Napier-Munn & Graham Jenkinson)
Measures of double stars with a DSLR camera and 35.5-cm reflector from 2008.781 to 2008.844 (Ernő Berkó)
A sequence of algorithms for the determination of binary star orbital elements and construction of the orbit relative to the apparent ellipse (Bill Oli18r)
Measurement of ten bright double stars using a Celestron Microguide eyepiece (Ian Coster)
Analysis of six neglected pairs in the WDS (Ian Coster)
A provisional orbit for STF 333 (WDS 02592+2120) (Ian Coster)
Measures of 36 anonymous and neglected southern visual double stars (Tófol Tobal & Xavier Miret)
OAG common proper motion wide pairs survey (Xavier Miret & Tófol Tobal)
Pp. 75, 2009

DSSC18: Micrometric measures of double stars in 2009 (Bob Argyle)
Micrometer measures of double stars in 2009 (Jean-François Courtot)
Measures of double stars with a DSLR camera and 35.5-cm reflector from 2008.852 to 2008.997 (Ernő Berkó)
Measures of double stars with a DSLR camera and 35.5-cm reflector from 2009.200 to 2009.835 (Ernő Berkó)
Measurement of some neglected southern multiple stars in Dorado and Pictor (Tim Napier-Munn & Graham Jenkinson)
Investigation of two anomalies in the WDSC (Tim Napier-Munn & Graham Jenkinson)
Five new visual double stars (Abdul Ahad)
Measures of 58 neglected southern visual double stars (Tòfol Tobal)
OAG Common proper motion wide pairs survey - Part II (OAG Supplement No. 24) (Xavier Miret & Tòfol Tobal)
Pp. 67, 2010

DSSC19: Micrometric measures of northern double stars in 2010 (Bob Argyle)
Micrometer measures of wide southern double stars (Bob Argyle)
The triple visual−eclipsing system CHR 175 (Thom Gandet)
High proper motion pairs from the SPM4 Catalog (John Greaves)
Common−motion pairs and other doubles found in spectral surveys − 1. Stephenson dwarfs and PG stars (Brian Skiff)
Measurements of visually discovered double stars between 1985−2007 (György Vaskúti)
Measures of double stars with a DSLR camera and 35.5−cm reflector from 2008.852 to 2008.997 (Ernő Berkó)
Lost Chevalier pairs? (Ernő Berkó)
Three new visual double stars (Abdul Ahad)
A new double star in Cygnus? (Peter Clark)
Second European Pro−Am meeting on double stars (Bob Argyle)
OAG common proper motion wide pairs survey − Part III (X. Miret, T. Tobal, A. Bernal, M. Bernal, I. Novalbos, J. A. Santos, & N. Miret)
Pp. 73, 2011

DSSC20 Micrometric measures of double stars in 2011 (Bob Argyle)
Micrometric measures of double stars in 2011 (Jean−François Courtot)
Astrometric measurements from 2010.7898 to 2011.6113 and six probable new pairs (Guiseppe Micello)
Measures of double stars near M39 (Mike Swan)
A new common proper motion pair in Serpens (Abdul Ahad)
A companion to the pulsating variable V1162 Tauri (Abdul Ahad)
Lost Chevalier pairs − a followup (Bill Hartkopf)
Observations of Visually Discovered Double Stars 1997 − 2011 (György Vaskúti)
Measures of double stars with a DSLR camera and 35.5−cm reflector on 2010.041 (Ernő Berkó)
Common−motion pairs and other doubles found in spectral surveys − 2. HD and miscellaneous stars (Brian Skiff)
Common−motion pairs and other doubles found in spectral surveys − 3. Lowell, Kuiper, Vyssotsky and other low−mass pairs (Brian Skiff)
An uncatalogued double star discovered by Ward (Bob Argyle and Ernő Berkó)
The wide triple system 14 Ari (Bob Argyle, Brian Skiff and Robert Kerr)
Measures of 74 equatorial neglected visual double stars RA: 00h00m to 05h59m −
OAG Common proper motion survey − Supplement 26 (Tòfol Tobal)
Pp. 89, 2012

DSSC21 Micrometric measures of double stars in 2012 (Bob Argyle)
Micrometric measures of double stars in 2012 (Jean−François Courtot)
Orbit and astrophysical study of WDS 12392−4022 = B1215 (Fernando Rica Romero)
Measures for 24 pairs in Capricornus (Abdul Ahad)
Three new cpm pairs in Capricornus (Abdul Ahad)
Measures of wide double stars using a webcam (Axel Tute)
Common−motion pairs and other doubles found in spectral surveys − 4. Faint M−dwarf doubles from the Sloan Digital Sky Survey (Brian Skiff)
Common−motion pairs and other doubles found in spectral surveys − 5. Miscellaneous pairs (Brian Skiff)
Common−motion pairs and other doubles found in spectral surveys − 6. Measures for known pairs (Brian Skiff)
Twenty one wide double stars in Aquila (Giuseppe Micello)
Pp. 107, 2013

DSSC22 Micrometric measures of double stars in 2013 (Bob Argyle)
Micrometric measures of wide southern double stars in 2013 (Bob Argyle)
The system J 868 (WDS 00152+2722) − a new optical double star with orbital parameters (F. M. Rica)
A new visual binary system in Cetus (Abdul Ahad)
A new visual double star in Orion (Abdul Ahad)
Measurement of 24 southern multiple stars (Graeme Jenkinson and Tim Napier−Munn)
Common−motion pairs and other doubles found in spectral surveys: − 7. Miscellaneous new and known pairs (Brian Skiff)
Pp. 54, 2014

DSSC23 Micrometric measures of double stars in 2014 (Bob Argyle)
Micrometric measures of double stars in 2014 (Jean−François Courtot)
Orbital solution and astrophysical parameters for WDS 09005+3225 (= HU 718) and WDS 11137+2008 AB (= STF 1517 AB) (Francisco Rica)
A new double star near Gamma Hydrae (Abdul Ahad)
Two new common proper motion doubles in Virgo (Abdul Ahad)
Measurement of nine neglected southern multiple stars (Graeme Jenkinson)
Common−motion pairs and other doubles found in spectral surveys − 8. One hundred forty new pairs found in the Orion complex (Brian Skiff)
Common−motion pairs and other doubles found in spectral surveys − 9. Survey work for 2014 (Brian Skiff)
New astrometric catalogue available from USNO (Brian Skiff)
Pp. 100, 2015

DSSC24 Micrometric measures of double stars in 2015 (Bob Argyle)
Micrometric measures of double stars in 2015 (Jean−François Courtot)
Measures of double stars at the Winer Observatory and discovery of new pairs (Andrè Debackére)
Discoveries of new pairs with the LCOGT network telescopes (T2M Faulkes telescope North, Hawaii and T1M McDonald, Texas) (Andrè Debackére)
Five new common proper motion double stars (Abdul Ahad)
Measures of 17 southern multiple stars) (Graeme Jenkinson)
Measureent of neglected southern multiple stars − two listed pairs and a possible new pair (Graeme Jenkinson)
Measures of multiple stars in Norma (Graeme Jennkinson)
A new visual double star in Aquila (Ian Coster)
Common−motion pairs and other doubles found in spectral surveys: − 10.
Survey work for 2015 (Brian Skiff)
Pp. 92, 2016

DSSC25 Micrometric measures of double stars in 2016 (Bob Argyle)
Micrometric measures of southern double stars in 2016 (Bob Argyle)
Micrometric measures of double stars in 2016 (Jean−François Courtot)
Some 2016 measurements of wide and faint double stars (Wilfried Knapp)
Double stars measurements with an astrometric eyepiece in 2016 (Neil Webster)
Two new visual common proper motion pairs (Kasper Wierzchos)
Measures of wide double stars with a webcam - II (Axel Tute)
Common−motion pairs and other doubles found in spectral surveys: − 11.
Survey work for 2016 prior to Gaia (Brian Skiff)
Measures of double stars with robotic telescopes (A. Debackére)
Study of the double star DBR 89 (A. Debackére)
Pp. 102, 2017