The Webb Society
Double Star Section Circulars No 15
Contents

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Editorial

With this issue of DSSC15 we continue to report work by double star observers around the world. The range of areas of interest and techniques which has been seen in previous editions continues with this copy. We welcome Andrew Soon and Tim Napier-Munn as new contributors, and welcome back Tamas Ladanyi, Ian Coster, Ricard Jaworski, Tofol Tobal and Martin Nicholson.

Starting with this edition of the Webb Society Double Star Section Circulars a decision has been reached to make this edition of the Double Star Section Circulars electronic and free to all. Recent paper editions have averaged 70 or 80 pages and producing enough copies of these was becoming more time-consuming, expensive, and wasteful of paper.

Previous issues of the Circulars will also be added to the website, as and when available. Some of the earlier issues will take some time to convert but to date numbers 6 to 14 inclusive have been installed and I am grateful to Tim Walker, the Webb Society webmaster for making space available for this.

To access the previous editions, as they appear, follow the link on the Bulletin Board at :
http://www.webbsociety.freeserve.co.uk/

The number of measures included in these Circulars is now 26901.

Observer	WDS code	Pairs	Measures	Method
R.W.Argyle	Ary	93	348	RETEL micrometer
I.Coster	Csr	13	39	Vixen illuminated cross-wire
T.Ladanyi	Lad	17	17	REDUC astrometry package
A.Soon	Soo	287	303	REDUC astrometry package
T.Tobal	Tob	1027	1027	GSC catalog data with astrometric software
TOTALS		1437	1734	

Bob Argyle,
2007 March

MICROMETER MEASUREMENTS FROM 2006.0 TO 2007.0

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Introduction

In this publication, the author presents his micrometric measurements which were largely made between 2006.0 and 2007.0. 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 author has continued to use the 8-inch f/14 Cooke refractor at the Observatories of the University of Cambridge. It is equipped with a RETEL micrometer at a power of x 450. In 2006, an additional magnification of x690 was used for a few observations, such as those of STF1670 after periastron passage. Using a Barlow lens, the screw constant is $12''.45$ per revolution which allows an equivalent reading accuracy of $\pm 0''.025$.

Measurements are arranged as usual (see Courtot & Argyle[1] for instance). Table 1 gives the name of the pairs using the WDS nomenclature[2] with the following codes:

A	Aitken, R. G.	AC	Clark, A.	BU	Burnham, S. W.
H	Herschel. W.	HJ	Herschel J.	S	South, J.
SHJ	South & Herschel	STF	Struve, F. G. W.	STT	Struve, O.
STTA	Struve, O. (Appendix)				

'Anon', for 'Anonymous', is used for pairs which have not been measured before.

The protocols followed here for measuring are very similar to earlier publications and consist basically of multiple double measures taken on several different evenings to get the final mean values of position angles and angular distances.

In the notes, for easier identification and historic measurements finding, following each pair, the ADS[3] or BDS[4] references are given. Then a short comment gives information on the observed motion, if any. For convenience, the apparent motions of optical pairs and orbital pairs are described in the same way. Table 3 gives the residuals from known orbits. The orbital elements come from the 6th USNO Catalogue of Orbits of Visual Binary Stars[5].

References

1) Courtot, J.-F. & Argyle, R. W., Webb Society Double Star Section Circulars, **12**, 1, 2004
2) 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
3) Aitken, R. G. : New General Catalogue of Double Stars Within 120° of the North Pole. Washington: Carnegie Institution of Washington, 1932.
4) Burnham, S. W. : A General Catalogue of Double Stars Within 121° of the North Pole. Washington: The Carnegie Institution of Washington, 1906.
5) 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

Table 1: Measures of double stars

Pair	Comp	RA	Dec	V_a	V_b	PA	Sep	Epoch	N	Obs.
STF3062		00063	+5826	6.42	7.32	342.2	1.49	2006.582	4	Ary
AC1		00209	+3259	7.27	8.26	290.7	2.01	2006.031	3	Ary
STF73	AB	00550	+2338	6.12	6.54	319.8	0.97	2006.015	4	Ary
S398	AB	01284	+0758	6.74	8.02	100.6	69.53	1994.494	2	Ary
STF162	Aa-C	01493	+4754	6.47	7.22	179.7	20.79	2003.948	4,5	Ary
STF202	AB	02020	+0246	4.10	5.17	270.9	2.12	2006.015	4	Ary
STF749	AB	05371	+2655	6.54	6.55	322.2	1.19	2006.173	3	Ary
STF795		05480	+0627	5.99	6.03	222.6	1.23	2005.465	4	Ary
STF982	AB	06546	+1311	4.75	7.80	146.1	7.18	2006.244	4	Ary
STF1066		07201	+2159	3.55	8.18	225.0	5.41	2006.264	4,3	Ary
STF1110	AB	07346	+3153	1.93	2.97	60.4	4.44	2005.285	8	Ary
STF1121	AB	07366	−1429	7.00	7.30	306.8	7.60	2006.268	3	Ary
BU1064	AD	08113	−1256	4.72	8.9	257.1	69.39	2006.257	3	Ary
BU1064	A?	08113	−1256	4.72		328.4	111.65	2006.274	2	Ary
STF1196	AB	08122	+1739	6.30	6.25	54.0	1.00	2006.251	5	Ary
STF1196	AB-C	08122	+1739	5.05	6.20	70.4	6.04	2006.263	7,6	Ary
STF1274		08490	+3821	7.42	9.34	42.5	9.35	2005.033	3	Ary
STF1356		09285	+0903	5.69	7.28	99.2	0.65	2006.281	3	Ary
STF1374	AB	09414	+3857	7.28	8.65	310.1	3.02	2004.582	3	Ary
STT215		10163	+1744	7.25	7.46	179.7	1.41	2006.053	3	Ary
STF1523	AB	11182	+3132	4.33	4.80	237.4	1.83	2006.340	6	Ary
STF1536	AB	11239	+1032	4.06	6.71	107.5	1.87	2006.320	3	Ary
STF1670	AB	12417	−0127	3.48	3.53	87.1	0.51	2005.273	4	Ary
STF1670	AB	12417	−0127	3.48	3.53	79.6	0.54	2005.396	4	Ary
STF1821		14135	+5147	4.53	6.62	236.0	13.62	2006.579	3	Ary
STF1864	AB	14407	+1625	4.88	5.79	111.8	5.34	2006.480	4	Ary
STF1871		14416	+5124	8.02	8.07	312.1	1.97	2006.568	4	Ary
STF1877	AB	14450	+2704	2.58	4.81	342.2	2.77	2006.518	4	Ary
STF1888	AB	14514	+1906	4.76	6.95	311.6	6.21	2006.482	9	Ary
STF1909		15038	+4739	5.20	6.10	57.7	1.78	2006.575	6	Ary
STF1937	AB	15232	+3013	5.64	5.95	127.6	0.55	2006.471	5	Ary
STF1954	AB	15348	+1032	4.17	5.16	172.1	3.98	2006.497	4	Ary
STF1962		15387	−0847	6.44	6.49	189.6	11.64	2006.497	3	Ary
STF1964	AC	15382	+3615	7.85	8.06	84.3	15.05	2006.621	3	Ary
STF1965		15394	+3638	4.96	5.91	305.9	6.28	2006.621	3	Ary
STF1967		15427	+2618	4.04	5.60	112.7	0.72	2006.476	4	Ary
STF1985		15559	−0210	7.03	8.65	352.6	6.13	2006.560	4	Ary
STF1998	AB	16044	−1122	5.16	4.87	347.0	0.82	2005.457	3	Ary
STF1998	AC	16044	−1122	4.87	7.30	40.5	7.85	2005.816	3	Ary
H 5 6	Aa-C	16120	−1928	4.20	6.60	336.0	41.16	2005.833	3	Ary
STF2032	AD	16147	+3352	5.62	10.78	82.1	90.53	2006.190	3	Ary
STF2055	AB	16309	+0159	4.15	5.15	33.4	1.48	2006.502	6	Ary
STF2084		16413	+3136	2.95	5.40	222.5	0.97	2005.474	1	Ary
STF2084		16413	+3136	2.95	5.40	205.5	0.99	2006.497	2	Ary
STF2130	AB	17053	+5428	5.66	5.69	10.9	2.21	2006.732	6	Ary
STF2122		17069	−0139	6.38	9.73	279.3	20.04	2006.194	3	Ary
STF3127	Aa-B	17150	+2450	3.14	8.3	285.1	12.20	2006.030	5	Ary
A2984		17166	−0027	4.92	7.51	10.6	1.04	2005.613	3	Ary
STF2191	AB	17398	−0458	7.83	8.47	267.3	26.56	2005.595	3	Ary
STF2272	AB	18055	+0230	4.22	6.20	135.1	5.00	2006.530	7	Ary

Pair	Comp	RA	Dec	V_a	V_b	PA	Sep	Epoch	N	Obs.
STF2276	AB	18057	+1200	7.09	7.44	257.9	6.74	2005.403	3	Ary
STF2276	AC	18057	+1200	7.09	11.03	305.4	62.38	2005.707	2	Ary
STF2276	BC	18057	+1200	7.44	11.03	311.6	58.40	2005.707	2	Ary
Anon		18278	+0244	6.06	10.5	110.6	87.47	2006.346	3	Ary
Anon		18400	+3051	6.44	10.12	100.5	53.58	2006.816	3	Ary
STF2367	AB-C	18413	+3018	7.05	8.75	13.8	13.96	2006.834	3	Ary
SHJ286		19050	−0402	5.52	6.98	211.1	39.00	2006.652	3	Ary
STF2425		19006	−0807	7.92	8.64	178.2	29.25	2006.163	3	Ary
STF2486	AB	19121	+4951	6.54	6.67	206.8	7.19	2006.015	4	Ary
STT588	AB	19250	+1157	5.24	8.65	286.3	101.66	2006.721	3	Ary
STT588	BC	19250	+1157	8.65	10.34	265.6	44.24	2006.732	3	Ary
STT371	AB	19159	+2727	7.03	7.55	161.2	0.82	2006.860	3	Ary
STT371	AB-C	19159	+2727	7.06	9.77	268.8	46.80	2006.860	3	Ary
STF2525		19266	+2719	8.19	8.39	290.2	2.06	2005.298	4	Ary
STF2578	AB	19457	+3605	6.37	7.04	125.9	14.90	2006.861	3	Ary
STF2583	AB	19487	+1149	6.34	6.75	106.5	1.51	2005.563	5	Ary
BU149	AB	19582	+1630	6.85	10.33	177.7	126.18	2006.746	3	Ary
AC12		19584	−0214	7.54	8.32	301.3	1.59	2004.465	3	Ary
Anon		19585	+1627	9.74	10.6	124.5	40.49	2006.746	3	Ary
STT395		20020	+2456	5.83	6.19	125.3	0.94	2006.827	4	Ary
STF2637	AC	20099	+2055	6.56	7.52	221.6	90.05	2006.809	3	Ary
STF2646	AB	20144	−0613	7.49	9.28	40.4	18.33	2006.531	3	Ary
STF2654		20152	−0330	6.96	8.14	233.2	14.11	2006.180	3	Ary
BU151	AB	20375	+1436	4.11	5.02	6.4	0.56	2006.824	3	Ary
STF2727		20467	+1607	4.36	5.03	266.6	9.04	2006.818	4	Ary
Anon		20471	+3210	7.42	8.82	236.8	98.82	2004.615	3	Ary
STF2737	AB	20591	+0418	5.96	6.31	289.7	0.65	2006.717	3	Ary
STF2737	AC	20591	+0418	5.96	7.05	68.2	10.37	2006.817	3	Ary
STF2745	Aa-B	21041	−0549	5.80	7.50	201.1	2.39	2006.838	3	Ary
STF2758	AB	21069	+3845	5.35	6.10	151.4	30.88	2006.610	3	Ary
STF2758	AH	21069	+3845	5.35	10.89	294.3	77.24	2006.836	3	Ary
Anon		21290	+2211			285.1	88.06	2006.534	3	Ary
STF2822	AB	21441	+2845	4.75	6.18	312.8	2.02	2006.090	5	Ary
STF2841	A-BC	21543	+1943	6.45	7.99	110.7	22.11	2006.016	3	Ary
HJ1721		22057	+2954	7.94	9.41	264.7	12.42	2005.943	3	Ary
Anon		22112	+2335	9.65		189.4	91.78	2005.557	3	Ary
STF2877	AB	22143	+1711	6.65	9.23	23.3	22.21	2006.002	3	Ary
STF2894	AB	22189	+3746	6.21	8.85	194.5	15.53	2005.057	3	Ary
SHJ345	AB	22266	−1645	6.29	6.39	26.3	1.37	2006.755	3	Ary
STF2909		22288	−0001	4.34	4.49	171.6	2.04	2006.810	9	Ary
STF2947	AB	22490	+6834	6.91	7.02	56.2	4.62	2004.071	4	Ary
STF2948		22496	+6633	7.26	8.60	4.6	2.85	2004.065	4	Ary
S826	AC	23141	−0855	7.60	9.10	129.2	75.81	2005.860	4	Ary
S826	BC	23141	−0855	9.5	11.7	114.0	67.41	2006.189	3	Ary
STF3050	AB	23595	+3343	6.46	6.72	334.5	2.22	2005.646	4	Ary

Table 2: Notes

Pair	ADS (BDS)	Notes
STF3062	61	Binary - see residuals.
AC1	285	Direct motion, widening. $+13°$, $+1''.6$ in 147 years.
STF73	755	36 And. Orbital pair. See residuals
S398	(770)	Little motion in 181 years.
STF162	1438	Little motion in 178 years.
STF202	1615	alpha Psc. Orbital pair - see residuals.
STF749	4208	Direct orbital motion - see residuals.
STF795	4390	Direct motion, getting slowly closer: $+21°$, $-0''.5$ in 182 years.
STF982	5559	38 Gem. Orbital motion. See residuals.
STF1066	5983	delta Gem. Orbital motion. See residuals.
STF1110	6175	alpha Gem. Orbital pair (P=445 yrs). Retrograde motion: $-9°$ in 187 yrs.
STF1121	6216	Slow direct motion :$+7°$. Getting wider: $+1''.1$ in 224 years.
BU1064	6647	E not in WDS. AD - retrograde relative motion: $-19°$. Getting wider: $+9''.0$ in 107 years.
STF1196AB	6650	zeta Cnc. Orbital pair. Third revolution since W. Struve's first observation in 1826. Last periastron in 1989. See residuals and also chap. 9 in RA's book.
STF1196AB-C	6650	Composite orbital pair (P=1115 yrs). Retrograde motion: $-82°$ in 177 yrs.
STF1274	7005	Little motion since 1830
STF1356	7390	omega Leo. Orbital pair -see residuals.
STF1374	7477	Direct motion: $+35°$ in 176 years. getting slowly closer, $-0''.3$.
STT215	7704	Orbital pair - see residuals.
STF1523	8119	xi UMa. Orbital pair - third revolution since W. Struve. See residuals.
STF1536	8148	iota Leo. Orbital pair (P=186 yrs). Retrograde relative motion: $-340°$ in 171 yrs. See residuals.
STF1670	8630	Opening after periastron passage in 2005. P=169.10 yrs - see residuals.
STF1821	9173	iota Boo. Retrograde relative motion: $-3°$ in 227 years. getting wider: $+1''.1$.
STF1864	9338	pi Boo. Direct motion: $+6°$ in 229 years. getting closer: $-1''.7$.
STF1871	9350	Direct motion: $+29°$ in 177 years.
STF1877	9372	epsilon Boo. Direct motion: $+42°$ in 206 years. Getting closer: $-1''.2$.
STF1888	9413	xi Boo. Orbital pair (P=152 yrs). See residuals.
STF1909	9494	44 Boo. Orbital pair (P=206 yrs). Next periastron in 2013. See residuals.
STF1937	9617	eta CrB. Fifth revolution since measure by W. Struve in 1826.
STF1954	9701	delta Ser. Retrograde orbital motion: -53° in 224 years. Geting wider: $+1''.5$.
STF1962	9728	Little change since 1825.
STF1964	9731	Getting closer $-1''.7$ in 204 years.
STF1965	9737	zeta CrB. Direct motion: $+10°$ in 227 years. Getting wider: $+0''.8$.
STF1967	9757	gamma CrB. Orbital pair - see residuals.
STF1985	9842	Direct relative motion: $+28°$ in 183 years. Getting slowly closer: $-0''.6$.
STF1998AB	9909	xi Sco. Orbital pair (P=45.68 years), now widening. See residuals
H 5 6	9951	nu Sco. Little change since 1877. Both components are double.
STF2032AD	9979	sigma CrB. Change due to pm of AB: $-9°$, $+48''$ in 181 years.
STF2055AB	10087	lambda Oph. Orbital pair (P=129 yrs). See residuals.
STF2084	10157	zeta Her. Orbital pair - see residuals.
STF2130AB	10345	mu Dra. Orbital pair (P= 672 years). See residuals.
STF2122	10347	Little change since 1831.
STF3127	10424	delta Her. Optical pair: $+92°$, $-22''$ since 1779. Widening.
A2984	10429	41 Oph. Orbital pair - see residuals.
STF2191	10693	Little change since 1831.
STF2272AB	11046	70 Oph. Third revolution since measure by W. Struve in 1825. Getting wider.
STF2276	11056	Retrograde relative motion: $-2°$ in 223 years. Getting closer: $-0''.9$.
Anon		A = HD 170137; B = TYC 437-1280-1. Not in WDS.
Anon		A = HD 172631; B = TYC 2637-2131-1. Not in WDS.
STF2367	11579	AB-C. Little change since 1832.
SHJ286	12007	Direct relative motion: $+4°$ in 205 years. Getting wider: $+5''.7$.
STF2425	(8947)	Retrograde relative motion: $-6°$ in 181 years. Getting closer: $-2''.8$.
STF2486	12169	Retrograde orbital motion: $-16°$ in 187 years. Getting closer: $-1''.8$.
STT588	-	31 Aql. AB: retrograde relative motion: $-78°$ in 154 years. Getting closer: $-41''$. BC: Direct relative motion: $+19°$ in 154 years. Getting slowly wider: $+1''.6$.
STT371	12239	AB: Direct motion: $+12°$ in 167 years. Getting slowly wider: $+0''.1$.

Pair	ADS (BDS)	Notes
STT371	12239	AB-C. Little motion since 1851.
STF2525	12447	Orbital pair - see residuals.
STF2578	12893	Little change since 1823.
STF2583	12962	pi Aql. Retrograde relative motion: −17° in 223 years.
BU149	13182	AB: Little change since 1873.
AC12	13178	Retrograde motion: −37° in 151 years. Getting wider: +0″.7.
Anon		A = HD 354303; B = HD 354304. Not in WDS.
STT395	13277	16 Vul. Orbital pair - see residuals.
STF2637	13312	Retrograde relative motion: −4° in 119 years. getting wider: +25″.5 .
STF2646	13552	Retrograde relative motion: −11° in 181 years. getting closer: −6″.8.
STF2654	13574	Little motion since 1822.
BU151AB	14073	beta Del. Now in fifth revolution since discovery (P= 26.65 years).
STF2727	14279	gamma Del. Retrograde orbital motion: −13° in 251 years. Getting closer: −3″.0.
Anon		A = HD 198108; B = +31° 4218. Not in WDS
STF2737	14499	epsilon Equ. AB - orbital pair - see residuals. AB-B retrograde relative motion: −9 ° in 22 years. Getting closer: −2″.0.
STF2745	14592	12 Aqr. Direct relative motion: +9° in 181 years. Getting closer: −0″.8.
STF2758AB	14636	61 Cyg. Long period orbital pair (P=659 yrs). Direct motion: +60° in 173 yrs, getting wider: +15″.2.
STF2758AH	14636	Important change since 1907 due to fast proper motion of AB (Piazzi's 'Flying Star'): 5″.9/yr in 57°.1.
Anon		Not in WDS.
STF2822	15270	mu Cygni. Orbital pair - see residuals.
STF2841	15431	Virtually no motion since 1823.
HJ1721	15620	Retrograde relative motion: −16° in 127 years. Getting wider: +4″.0.
Anon		A = +22° 4572. B = IRAS 22088+2316?
STF2877	15763	Direct relative motion: +73° in 169 years. Getting rapidly wider: +17″.2.
STF2894	15828	Little angular motion in 227 years. Getting wider: +1″.8.
Anon		A = +21° 4572. B = ? Not in WDS.
SHJ345AB	15934	53 Aqr. Very long period orbital pair (P=3500 yrs). Periastron in 2023. Direct motion (+58° in 180 yrs), getting closer: −8″.5. See residuals.
STF2909	15971	zeta Aqr. Long period orbital pair (P=760 yrs). Retrograde motion (−198° in 222 years), getting closer: −2″.6. See residuals.
STF2947	16291	Retrograde relative motion: −23° in 177 years. getting wider: +1″.1
STF2948	16298	Little angular motion since 1830. getting slowly closer: −0″.4.
S826	16611	AB: Direct relative motion: +20° in 182 years. Getting rapidly closer: −72″.4. BC: Direct relative motion: +13° in 161 years. Getting rapidly closer: −75″.7.
STF3050	17149	Binary - see residuals.

Table 3: Residuals from known orbits

Pair	ADS	Residual(O−C)	Period(yrs)	Orbit	Date	Grade
STF3062	61	+2°.4, +0″.16	106.7	Söderhjelm	1999	2
STF73	755	+1°.6, −0″.03	167.71	Docobo	1990	2
STF202	1615	+3°.4, +0″.33	933	Scardia	1983	4
STF749	4208	+0°.2, +0″.03	986.6	Scardia	2005	4
STF982	5559	+3°.1, +0″.01	3190	Hopmann	1952	5
STF1066	5983	−1°.4, −0″.25	1200	Hopmann	1960	5
STF1110AB	6175	+0°.7, +0″.07	444.945	Docobo	1985	3
STF1196AB	6650	+3°.0, +0″.01	59.56	Söderhjelm	1999	1
STF1196AB-C	6650	+0°.9, +0″.05	1115.0	Heintz	1996	4
STF1356	7390	+2°.0 −0″.02	118.227	van Dessel	1976	2
STT215	7704	−0°.4, −0″.08	151.6	Söderhjelm	1999	2
STF1523	8119	+0°.4, +0″.14	59.878	Mason	1995	1
STF1536AB	8148	+3°.5, 0″.00	186.0	Söderhjelm	1999	2
STF1670AB	8630	−0°.4, +0″.05	169.10	Scardia	2006	2
STF1670AB	8630	−1°.7, +0″.05	169.10	Scardia	2006	2

Pair	ADS	Residual(O−C)	Period(yrs)	Orbit	Date	Grade
STF1888AB	9413	−0°.4, −0″.08	151.6	Söderhjelm	1999	2
STF1909	9494	+0°.5, −0″.12	206	Söderhjelm	1999	3
STF1937AB	9617	+0°.2, +0″.04	41.585	Mason	1999	1
STF1954	9701	−0°.9, −0″.01	1038	WSI	2002	4
STF1967	9757	−0°.3, −0″.02	92.94	Hartkopf	1989	2
STF1998AB	9909	+0°.7, +0″.02	45.68	Söderhjelm	1999	1
STF2055	10087	−0°.8, +0″.03	129.0	Heintz	1993	2
STF2084	10157	−2°.0, −0″.01	34.45	Söderhjelm	1999	1
STF2084	10157	−4°.3, −0″.05	34.45	Söderhjelm	1999	1
STF2130	10345	+1°.1, −0″.10	672.	Heintz	1981	4
A2984	10429	−0°.2, 0″.00	206.31	Olevic	1993	5
STF2272	11046	−0°.4, −0″.16	88.38	Pourbaix	2000	1
STF2486	12169	+1°.2, −0″.22	3100	Hale	1994	4
BU151	14073	+0°.2, +0″.02	26.65	Alzner	1998	1
STF2727	14279	+1°.1, −0″.10	3249	Hale	1994	4
STF2758AB	14636	+0°.9, +0″.27	659	Kiseleva	1997	4
STF2822	15270	−0°.2, +0″.28	789	Heintz	1975	4
SHJ345AB	15934	0°.0, −0″.03	3500	Hale	1994	5
STF2909	15971	+4°.0, −0″.08	760	Heintz	1984	4
STF2909	15971	+6°.0, −0″.10	587.18	Olevic	2004	3
STF3050	17149	+0°.7, +0″.16	320	Starikova	1977	3

MEASURES OF DOUBLE STARS WITH A CCD CAMERA AND 25-CM CASSEGRAIN REFLECTOR IN 2006

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These measures have been made at Castor Observatory, located in Veszprém, Hungary at latitude 47.1047 North, longitude 17.9083 East, altitude 234m. It is my private observatory in the garden of my house in the suburb area of the city. The telescope used is a 25 cm homemade Cassegrain reflector. It is equipped with an ATK 1 HS CCD camera, which has 640×480 pixels. The combination of the CCD and the telescope results in pixels that are 0.292 arcsec square.

I found the software called REDUC (version 3.62) by Florent Losse easy to use with the help of calibration stars. Before the beginning of the measures I always calibrate my equipment with a fixed pair from the list of Guy Morlet (SIDoNie database) or György Vaskúti (based on WDS and Tycho). I use the centroiding algorithm of the software calculating with the stars of the selected best pictures. REDUC also calculates the standard deviation for PA and separation. They are given in the σ_θ and σ_ρ columns, respectively.

Table 1: Measures of double stars

RA(2000)Dec		Pair	Comp	V_A∗	V_B∗	Sep (″)	σ_ρ (″)	PA (°)	σ_θ (°)	2000+	N	Not
00079	+7807	MLR 369	AB	11.30	11.16	2.10	0.1	48.87	0.37	6.773	15	
00152	+7801	STF 11		8.48	10.14	8.13	0.11	192.92	0.34	6.773	18	
00327	+7807	STF 34		9.61	9.71	5.79	0.08	339.4	0.38	6.773	24	
00444	+7713	STF 50		8.01	10.62	22.31	0.09	95.81	0.33	6.773	38	
00505	+7538	HJ 1997		10.56	10.68	17.71	0.08	47.38	0.3	6.773	39	

RA(2000)Dec		Pair	Comp	V_A*	V_B*	Sep (″)	σ_ρ (″)	PA (°)	σ_θ (°)	2000+	N	Not
01070	+8005	FOX 3	AB	10.0	12.6	4.03	0.09	149.78	0.47	6.773	6	
01107	+8021	STF 89		9.72	10.02	16.57	0.1	322.24	0.28	6.773	39	
01191	+8052	STT 28	AB	7.55	8.75	0.87	0.42	296.19	0.46	6.773	3	
01191	+8052	BU 1359	CD	7.17	11.69	69.78	0.16	155.1	0.19	6.773	42	
02474	+1713	CHE 69		8.2	10.6	28.24	0.13	351.78	0.19	6.932	13	1.
10588	+6143	STF1491		8.39	11.33	14.12	0.14	33.01	0.31	6.467	30	
11057	+6237	STF1505	AB	8.95	10.55	8.14	0.05	312.36	0.32	6.361	27	
11057	+6237	Anon	AD	8.95	12.7	32.73	0.22	108.19	0.51	6.361	14	2.
11092	+6230	STF1512	AB	9.29	9.52	9.92	0.04	50.95	0.22	6.361	18	
11098	+6123	ES1906		10.0	10.5	4.49	0.21	275.09	0.63	6.467	4	
11098	+6320	H 4 106		7.9	11.4	20.19	0.08	134.2	0.21	6.467	23	
23239	+7704	STF3011		9.23	9.44	6.89	0.06	332.02	0.37	6.773	34	

Notes
1. GSC12231346 and GSC12231410, non star object (12.7 magnitude) in software Guide 7.0
2. D=GSC4149 289, 12.7 magnitude, closer than the component C, can't be found in WDS.
* Magnitudes from the WDS 2006.5
N = Number of frames

CCD OBSERVATIONS OF DOUBLE STARS AT WAVERLEY OBSERVATORY

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Abstract

This report contains 303 measurements of neglected double stars from the WDS Northern List. The instrumentation utilized was a 12-inch RCX400 at f8 and a CCD camera to record the images. Data reduction was done using REDUC software.

Telescope

The telescope is a Meade RCX400 of 12-inch aperture with a 38% central obstruction by diameter. The telescope is mounted in Alt/Az and therefore each binary system that is imaged must contain a drift image to determine the correct PA orientation. Calibration of the PA and Sep was determined by imaging a known calibration pair from the Sixth Catalog of Orbits of Visual Binary Stars.

Images are taken without any additional amplification at a focal length of 2438 mm providing 0.71 arc seconds per pixel on the CCD detector.

CCD Detector

The CCD detector is a Meade DSI Pro II. The Pixel size is 8.6x8.3 arranged in a 752x582 array on a Sony ICX429ALL image sensor. No binning was employed. The shutter is electronic and there is no cooling used.

Figure 1: Andrew Soon and his 12-inch RCX400 telescope

Data Reduction

All double star images were reduced using REDUC software kindly provided by Florent Losse. With careful technique it was possible to generate highly accurate and repeatable values for PA and Sep. To ensure the accuracy of the measurements, I utilized an initial calibration candidate from the Sixth Catalog of Orbits of Visual Binary Stars to calibrate the system and followed up with one blind calibration candidate from the WDS Neglected Doubles List.

Notes

1). Comparative results of this blind calibration are as follows:
2). DSS2.J.POSSII source for magnitude of components A and B
3). DSS2.J.POSSII source for magnitude of components A and B

19121	+4951	STF2486	AB	2006.00	205.6	7.405	(USNO Sixth Orbit Catalogue)
				2006.6137	205.15	7.435	(WO)

References and acknowledgements

1). This publication makes use of 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.
2). The Washington Double Star Catalog.
3). Sixth Catalog of Orbits of Visual Binary Stars.

Table of measurements

Pair	Comp	RA	Cec	V_a	V_b	PA	Sep	2000+	N	Obs	Notes
SLE 139		18077	+5632	10.1	12.3	334.31	6.607	6.6761	1	Soo	
AG 221	AC	18200	+2120	9.1	12.1	10.97	10.856	6.6761	1	Soo	
ES 2173		18267	+3610	7.7	11.9	304.35	6.474	6.6761	1	Soo	
MLB 854		18272	+3847	11.8	12.0	10.38	6.675	6.6761	1	Soo	
OB 151		18344	+3200	10.4	11.2	287.12	25.460	6.6761	1	Soo	

Pair	Comp	RA	Cec	V_a	V_b	PA	Sep	2000+	N	Obs	Notes
SLE 95		18365	+4008	10.9	11.6	109.84	10.650	6.6761	1	Soo	
ES 2482		18445	+3733	10.0	10.5	162.30	11.531	6.6761	1	Soo	
SLE 119		18454	+3005	11.0	11.6	176.01	6.617	6.6761	1	Soo	
SLE 121		18462	+3116	11.6	11.7	350.01	12.026	6.6761	1	Soo	
ES 2484		18463	+3745	11.0	11.2	333.27	6.528	6.6761	1	Soo	
ES 2023		18484	+3612	8.7	12.0	246.95	6.298	6.6788	1	Soo	
COU 318		18511	+2253	9.1	12.5	285.88	3.392	6.6788	1	Soo	
STI 865		18519	+5948	10.4	10.9	178.89	3.154	6.6788	1	Soo	
MLB 651		18537	+3012	10.7	12.3	66.17	4.588	6.6788	1	Soo	
MLB 215		18538	+6509	10.5	10.6	192.50	3.447	6.6788	1	Soo	
ELS 7	AB	18546	+3656	11.0	11.3	341.99	8.823	6.6788	1	Soo	
ES 2422		18569	+3112	9.1	12.1	177.26	5.480	6.6788	1	Soo	
BEM 36		18588	+5307	11.5	10.4	338.50	11.306	6.6788	1	Soo	
HLM 14		19002	+3122	10.5	10.5	321.20	13.328	6.5945	1	Soo	
ES 1429	AB	19005	+4313	10	11	15.27	6.651	6.6495	1	Soo	
MLB 758	AC	19009	+3714	9.6	10	147.12	8.864	6.6137	1	Soo	
MLB 758	AC	19009	+3714	9.6	10.0	147.95	9.400	6.6788	1	Soo	
ES 2671		19028	+5150	10.7	10.9	288.37	8.368	6.6137	1	Soo	
HJ 1364		19032	+4428	10.71	10.88	208.42	2.926	6.6379	1	Soo	
GCB 34		19038	+2756	11.5	12.0	294.36	6.435	6.6788	1	Soo	
J 1209		19045	+3406	9.5	10	154.68	4.575	6.6495	1	Soo	
J 2941		19047	+2850	10.8	12.5	233.80	8.556	6.6788	1	Soo	
AG 372	AB	19050	+2904	9.5	10.8	184.43	6.144	6.6495	1	Soo	
J 767	AC	19064	+3750	9.5	12.0	180.33	7.894	6.6788	1	Soo	
STI2415		19074	+5618	11.3	11.7	359.12	3.573	6.6788	1	Soo	
STF2473	CD	19086	+3755	10.29	10.45	294.47	6.078	6.6342	1	Soo	
J 2946		19097	+2112	9.6	10.2	52.76	4.316	6.6495	1	Soo	
ES 350		19108	+3207	9.1	9.9	237.37	5.450	6.6495	1	Soo	
STF2486	AB	19121	+4951	6.54	6.67	205.15	7.435	6.6137	2	Soo	1
HO 445		19124	+2435	9.8	10.9	243.06	5.382	6.6495	1	Soo	
MLB 694		19133	+2719	10	10.2	123.88	3.820	6.6379	1	Soo	
ES 2174		19136	+3622	10.6	10.7	159.42	5.845	6.6495	1	Soo	
ES 1752		19151	+5924	9.6	12.2	325.21	2.688	6.6788	1	Soo	
BRT1923		19153	+4322	10.2	10.3	188.22	3.475	6.6379	1	Soo	
MLB 525		19163	+2823	11	12	23.35	5.916	6.6495	1	Soo	
MLB 860		19183	+3821	12.79	13.3	181.45	5.790	6.6495	1	Soo	
WFC 219		19186	+2038	10.2	10.38	71.14	8.677	6.6137	1	Soo	
BU 360	AB	19187	+3514	8.5	10.1	67.60	6.603	6.6495	1	Soo	
HJ 1386		19191	+4801	9.5	9.6	325.01	11.051	6.6137	1	Soo	
ES 2113		19192	+3715	10	10	339.32	4.596	6.6495	1	Soo	
HJ 1383		19192	+3133	10	10	112.60	12.663	6.5945	1	Soo	
ES 1562	AB	19193	+4217	9.5	9.9	323.48	5.977	6.6495	1	Soo	
J 769		19203	+2914	9.7	9.9	206.51	3.735	6.6379	1	Soo	
VKI 34		19207	+4127	10.5	12.5	328.84	2.850	6.6788	1	Soo	
ES 2491		19212	+3720	10.7	10.8	1.62	5.099	6.6495	1	Soo	
ES 2491		19212	+3720	10.7	10.8	358.93	4.556	6.6788	1	Soo	
J 770		19221	+2907	9.7	10.8	16.27	3.389	6.6379	1	Soo	
MLB 862		19224	+3823	8.9	10.9	53.39	10.487	6.6788	1	Soo	
MLB 862		19224	+3823	8.9	10.9	55.83	10.312	6.6137	1	Soo	
MLB 863		19226	+3825	11.53	12.6	273.39	7.533	6.6342	1	Soo	

Pair	Comp	RA	Cec	V_a	V_b	PA	Sep	2000+	N	Obs	Notes
STI2429		19229	+5430	12.5	12.5	104.11	4.376	6.6788	1	Soo	
SEI 593		19237	+3938	10.3	11	43.20	14.897	6.5945	1	Soo	
ES 2492		19240	+3759	10	10.5	156.84	7.849	6.6137	1	Soo	
ES 2492		19240	+3759	10.0	10.5	154.53	7.557	6.6788	1	Soo	
BRT1924		19245	+4259	9.9	9.9	68.44	4.525	6.6379	1	Soo	
MLB 865		19253	+3918	10	10.5	7.40	9.131	6.6495	1	Soo	
MLB 865		19253	+3918	10.0	10.5	6.99	9.414	6.6788	1	Soo	
SEI 597		19254	+3443	8.9	10.9	319.52	12.757	6.5945	1	Soo	
MLB 759		19256	+3236	10.8	11.0	309.76	4.032	6.6788	1	Soo	
COU 17		19257	+3557	9.5	10.8	48.77	3.460	6.6379	1	Soo	
MLB 760		19257	+3234	9.7	10.3	188.03	5.051	6.6379	1	Soo	
MLB 472		19260	+2830	10.5	10.9	350.08	10.815	6.6137	1	Soo	
MLB 866	AC	19260	+3911	11.88	12.3	88.08	17.571	6.5945	1	Soo	
HJ 1396		19262	+3028	12.	12.	82.26	11.298	6.6788	1	Soo	
HJ 1401		19262	+4723	9.5	10.2	186.15	18.046	6.5945	1	Soo	
SEI 602		19266	+3934	11.61	11.74	157.30	4.008	6.6379	1	Soo	
HO 451		19268	+2752	9.3	11	282.05	3.619	6.6379	1	Soo	
MLB 569	CD	19268	+2929	10.23	11.69	218.10	7.724	6.6788	1	Soo	2
ES 2493		19273	+3727	9.7	10.8	299.64	8.072	6.6788	1	Soo	
ES 2493		19273	+3727	9.7	10.8	302.16	7.751	6.6271	1	Soo	
ES 353		19274	+3320	9.2	10.8	298.99	3.530	6.6379	1	Soo	
ES 2036		19277	+3804	10.6	12.5	140.54	3.033	6.6788	1	Soo	
MLB 867		19278	+3911	10	11	233.34	6.083	6.6495	1	Soo	
STF2530		19284	+2019	9	10.3	158.59	5.565	6.6495	1	Soo	
HJ 1404	AB	19288	+4617	9.8	10.3	131.92	5.896	6.6495	1	Soo	
MLB 868		19290	+3930	12	12.4	174.80	3.126	6.6379	1	Soo	
HJ 2876		19293	+2246	10.2	11	97.03	11.358	6.5945	1	Soo	
HJ 1405		19294	+4052	10.8	11.8	58.35	8.964	6.6788	1	Soo	
J 2973		19299	+2520	9.9	10.5	186.73	5.933	6.6495	1	Soo	
MLB 978	AB	19300	+4010	10.5	11	145.13	4.818	6.6379	1	Soo	
STF2546	AB	19300	+6630	8.8	11	9.88	8.692	6.6137	1	Soo	
HJ 1406	AB	19303	+3320	11.63	11.86	300.17	12.327	6.6342	1	Soo	
MLB 697	AB	19303	+2911	10.7	12.3	6.57	7.172	6.6788	1	Soo	
MLB 697	AC	19303	+2911	10.7	10.7	100.55	4.497	6.6788	1	Soo	
SEI 613		19311	+3146	11	11	0.73	16.710	6.5945	1	Soo	
SEI 621		19322	+3457	11.47	12.72	57.62	16.436	6.5945	1	Soo	
BRT2238		19327	+4438	10.7	10.7	204.10	5.419	6.6495	1	Soo	
GYL 18		19332	+3330	12.26	12.8	308.96	8.092	6.6137	1	Soo	
J 2977		19335	+2401	9.9	11.5	251.24	6.794	6.6788	1	Soo	
SEI 630		19335	+3611	9.43	10.78	31.72	15.083	6.5945	1	Soo	
SEI 633		19336	+3519	11	11	86.99	12.771	6.5945	1	Soo	
SLE 629		19336	+2950	11.7	11.8	120.66	4.911	6.6788	1	Soo	
SEI 637		19338	+3836	10.5	11	95.28	14.503	6.5945	1	Soo	
MLB 870		19339	+3916	12.73	13.23	255.96	10.349	6.6342	1	Soo	
MLB 871		19339	+3915	11.18	12.4	193.37	9.072	6.6137	1	Soo	
STI2441		19340	+5514	12.4	12.4	34.68	12.729	6.6788	1	Soo	
BRT2240		19344	+3954	10.6	11	59.38	5.112	6.6495	1	Soo	
HJ 1416		19347	+3152	10	11	236.79	10.291	6.6495	1	Soo	
MLB 656		19350	+2920	11.17	12.1	134.31	8.521	6.6788	1	Soo	
MLB 656		19350	+2920	11.71	12.1	134.39	8.786	6.6495	1	Soo	

Pair	Comp	RA	Cec	V_a	V_b	PA	Sep	2000+	N	Obs	Notes
POU3940		19352	+2501	10.6	10.7	24.75	10.225	6.6137	1	Soo	
ROE 19		19355	+3523	10	10	162.71	9.689	6.6137	1	Soo	
ROE 19		19355	+3523	10.	10.	159.61	9.489	6.6816	1	Soo	
SLE 642		19356	+2900	11.4	11.8	113.34	5.810	6.6816	1	Soo	
STF2548		19365	+2500	8.47	9.85	99.23	9.759	6.6137	1	Soo	
BRT 267		19367	+3052	11.5	12.83	345.99	5.334	6.6495	1	Soo	
HJ 1424		19373	+3254	11	11	29.55	15.832	6.6379	1	Soo	
SEI 650	AB	19373	+3555	10.91	11.65	150.65	16.844	6.5945	1	Soo	
ES 2495		19374	+3811	10.5	11	144.23	5.727	6.6495	1	Soo	
ES 2495		19374	+3811	10.5	11.0	149.88	6.090	6.6816	1	Soo	
HJ 1425		19377	+3255	10	11	240.00	13.964	6.6379	1	Soo	
HJ 1429		19379	+5614	10.6	11	239.09	8.136	6.6137	1	Soo	
STN 47		19385	+3812	9.5	11	214.77	4.156	6.6495	1	Soo	
POU3973	AC	19386	+2455	10.87	12.91	228.68	7.942	6.6137	1	Soo	
ES 2497		19388	+3742	9.5	11	256.20	4.365	6.6495	1	Soo	
BKO 76	DE	19394	+3029	12.1	12.5	257.65	3.439	6.6816	1	Soo	
STI2447		19398	+5654	11.2	12.1	325.05	6.569	6.6816	1	Soo	
A 272	AC	19402	+2611	9.77	10.45	308.38	15.253	6.5945	1	Soo	
MLB1084		19405	+6946	9.5	10.7	96.21	10.790	6.6137	1	Soo	
STI2448		19410	+5447	10.8	12.3	196.50	7.596	6.6816	1	Soo	
MLB 875		19412	+4058	10	10.1	190.26	6.035	6.6495	1	Soo	
MLB 875		19412	+4058	10.0	10.1	191.20	5.918	6.6816	1	Soo	
MLB 526		19413	+2835	10	11	12.42	8.075	6.6495	1	Soo	
MLB 526		19413	+2835	10.0	11.0	12.50	8.274	6.6816	1	Soo	
HJ 1430	AB	19414	+3313	10.31	11.54	154.34	18.407	6.5945	1	Soo	
MLB 527		19421	+2852	10.4	10.7	166.25	6.538	6.6816	1	Soo	
MLB 527		19421	+2852	10.4	10.7	166.73	6.845	6.6495	1	Soo	
HJ 2896		19425	+5655	9.94	11.32	21.31	17.636	6.5945	1	Soo	
J 122		19430	+3526	9.3	12.3	53.01	9.710	6.6816	1	Soo	
POU4026	AB	19432	+2318	9	10.5	302.32	9.354	6.6137	1	Soo	
J 778	AC	19436	+3339	9.2	9.7	283.82	4.704	6.6379	1	Soo	
J 1193	AB	19453	+2402	12.87	12.96	272.41	4.560	6.6495	1	Soo	
ALI 161	AB	19457	+3612	10.8	11	17.68	8.870	6.6137	1	Soo	
A 601	AC	19458	+4145	9.9	10.9	359.46	6.648	6.6495	1	Soo	
ES 2575		19458	+3936	10.6	10.6	2.96	3.799	6.6379	1	Soo	
SEI 678		19460	+3825	11	11	140.40	11.132	6.5945	1	Soo	
MLB 979		19470	+3926	10	10.2	29.28	6.087	6.6379	1	Soo	
STI2457		19470	+5800	11.9	11.9	170.31	9.742	6.6816	1	Soo	
MLB 528		19473	+2819	11.92	12.81	24.92	7.112	6.6495	1	Soo	
MLB 980		19474	+3926	9.8	10.5	28.99	6.188	6.6379	1	Soo	
SMA 93		19474	+4515	10.0	12.0	197.65	10.648	6.6816	1	Soo	
GCB 74		19475	+3346	11.20	11.67	139.85	6.250	6.6816	1	Soo	3
BRT 43		19477	+2924	12.1	12.1	107.10	4.553	6.6816	1	Soo	
J 3007		19480	+2333	9.9	11.8	228.92	6.288	6.6816	1	Soo	
WFC 226		19480	+3206	8.9	10.97	300.21	9.368	6.6137	1	Soo	
STI 924		19481	+6059	10.3	10.3	160.30	10.568	6.5945	1	Soo	
HLM 31		19483	+3710	10.7	11.5	294.91	11.752	6.6816	1	Soo	
GYL 21		19492	+3253	10.5	10.7	164.22	6.948	6.6342	1	Soo	
SEI 692		19500	+3407	10.3	10.3	12.43	2.935	6.6379	1	Soo	
CHE 155		19501	+2325	9.7	11.5	268.22	5.135	6.6816	1	Soo	

Pair	Comp	RA	Cec	V_a	V_b	PA	Sep	2000+	N	Obs	Notes
SMA 100		19504	+4446	10.0	12.5	334.60	10.651	6.6816	1	Soo	
J 3018		19505	+2030	10.6	10.8	164.29	6.928	6.6816	1	Soo	
SMA 101		19509	+4444	12.0	12.5	48.15	9.617	6.6816	1	Soo	
SEI 697		19510	+3443	10.3	10.7	308.57	3.891	6.6379	1	Soo	
SEI 698		19510	+3650	10.5	11	17.24	17.708	6.5945	1	Soo	
SMA 104		19512	+3724	12.57	13.01	51.05	8.160	6.6137	1	Soo	
J 3021		19516	+2810	9.7	11	179.10	5.462	6.6379	1	Soo	
MLB 698		19517	+2745	10.5	10.6	349.85	5.861	6.6342	1	Soo	
SEI 705		19518	+3501	10.4	10.7	131.66	9.680	6.6137	1	Soo	
SEI 706		19519	+3407	10.2	10.7	139.44	12.620	6.5945	1	Soo	
ES 2428	BC	19521	+3148	11.1	11.1	254.60	4.888	6.6816	1	Soo	
BRT2244		19522	+4238	10.4	11	221.92	4.157	6.6495	1	Soo	
ROE 20		19526	+3624	12.66	12.76	159.31	5.394	6.6495	1	Soo	
SEI 709		19527	+3425	11.64	12.31	330.30	13.466	6.5945	1	Soo	
MLB 943		19529	+3934	10.5	10.6	244.47	4.547	6.6816	1	Soo	
MLB 767		19530	+3856	10.2	10.5	125.26	8.045	6.6816	1	Soo	
MLB 767		19530	+3856	10.2	10.5	128.44	8.061	6.6137	1	Soo	
MLB 944		19530	+3936	9.5	10.7	153.78	7.638	6.6137	1	Soo	
MLB 946		19534	+3934	10.5	10.5	216.35	5.448	6.6495	1	Soo	
SEI 714		19534	+3640	11	11	55.04	11.178	6.5945	1	Soo	
SEI 717	AB	19535	+3859	11	11	108.80	4.562	6.6379	1	Soo	
HJ 1450		19536	+3017	10.5	10.5	252.52	8.731	6.6137	1	Soo	
SEI 719		19539	+3923	11.51	12.23	58.45	16.431	6.5945	1	Soo	
ES 2686		19540	+4915	8	11	303.12	20.305	6.5945	1	Soo	
ROE 145		19541	+4236	9.8	10.6	252.21	12.180	6.5945	1	Soo	
BRT2246		19542	+4621	10	10.4	49.96	5.024	6.6495	1	Soo	
BRT 204		19553	+2813	10.6	11	319.02	4.942	6.6379	1	Soo	
SEI 729		19553	+3741	10.5	11	256.96	12.049	6.5945	1	Soo	
MLB 877		19558	+3918	11.5	12.5	34.11	5.328	6.7281	1	Soo	
HLM 34		19561	+3457	10	11.01	9.92	10.480	6.6137	1	Soo	
HLM 34		19561	+3457	10.0	11.0	13.05	10.290	6.7281	1	Soo	
J 500		19570	+2438	12.18	12.98	297.73	4.076	6.6379	1	Soo	
MLB 948		19570	+3836	10.7	11.7	10.32	5.570	6.7281	1	Soo	
HJ 1460		19573	+4648	9.9	11	85.44	6.845	6.6342	1	Soo	
SEI 744		19573	+3927	11	11	86.19	17.084	6.5945	1	Soo	
HLM 35		19576	+3454	10.7	10.9	265.98	7.738	6.6137	1	Soo	
BRT2248		19577	+4359	9.8	10.3	136.05	5.787	6.6495	1	Soo	
HJ 1457		19577	+3755	9.7	9.93	221.34	12.562	6.5945	1	Soo	
SEI 748		19578	+3508	11.33	12.7	35.67	5.186	6.6342	1	Soo	
SEI 750		19578	+3842	10.5	11	28.74	7.794	6.6326	1	Soo	
SEI 760		19590	+3759	10.5	11	339.91	4.960	6.6342	1	Soo	
SEI 765	AB	19592	+3702	11	11	94.16	7.573	6.6137	1	Soo	
MLB 605		20002	+2759	9.4	10.9	178.12	8.111	6.7281	1	Soo	
MLB 605		20002	+2759	9.4	10.9	180.67	8.257	6.6679	1	Soo	
ROE 10		20002	+2251	10	10	65.49	9.094	6.6679	1	Soo	
SEI 780		20005	+3418	11	11	164.83	6.044	6.6679	1	Soo	
BRT 273		20007	+3130	9.9	12.2	76.43	4.544	6.7281	1	Soo	
BRT2250		20011	+4045	10.7	10.7	10.86	5.125	6.6506	1	Soo	
SEI 791		20011	+3913	10.5	11	57.97	5.610	6.6679	1	Soo	
SEI 794		20016	+3358	11	11	193.06	3.800	6.6506	1	Soo	

Pair	Comp	RA	Cec	V_a	V_b	PA	Sep	2000+	N	Obs	Notes
SEI 801		20022	+3332	9.8	10.3	106.44	7.727	6.6679	1	Soo	
BRT2251		20025	+3940	9.3	10.5	149.63	4.465	6.6506	1	Soo	
HO 117		20025	+3341	9.1	10.4	313.51	5.219	6.6679	1	Soo	
J 3045		20025	+2836	9.8	9.9	263.74	4.996	6.6679	1	Soo	
SEI 825		20033	+3807	10	10.8	152.66	7.195	6.6679	1	Soo	
SEI 833		20039	+3349	9.8	10	326.51	6.184	6.6679	1	Soo	
POU4199		20041	+2514	11.3	12.5	84.78	2.194	6.7281	1	Soo	
MLB 702		20046	+2719	10.5	10.8	44.13	6.756	6.6679	1	Soo	
MLB 606		20053	+2756	10.6	10.8	35.18	7.388	6.6679	1	Soo	
SEI 847		20054	+3539	10.5	11	7.40	4.659	6.6506	1	Soo	
ES 1329		20061	+4500	8.2	10.7	209.58	8.847	6.6679	1	Soo	
SEI 876		20064	+3442	10.5	11	13.60	4.311	6.6506	1	Soo	
SEI 881		20068	+3203	9.5	9.7	311.94	7.308	6.6679	1	Soo	
BRT2252		20073	+4013	11.9	12.05	175.98	2.416	6.6506	1	Soo	
POP 188		20075	+3749	10.0	12.0	63.53	4.135	6.7281	1	Soo	
SEI 904		20078	+3603	10	10.7	269.02	14.125	6.6679	1	Soo	
SEI 908		20079	+3605	11	11	14.36	3.376	6.6506	1	Soo	
ES 203		20084	+3528	9.5	10.7	128.20	6.237	6.6679	1	Soo	
MLB 529		20085	+2842	9.4	10	54.41	4.613	6.6506	1	Soo	
MLB 768		20085	+3936	10	10.1	109.89	5.128	6.6506	1	Soo	
MLB 768		20085	+3936	10.0	10.1	113.72	4.874	6.7281	1	Soo	
BRT2467		20086	+2041	10.6	11	55.59	3.806	6.6506	1	Soo	
SEI 910		20087	+3130	11	11	106.08	12.412	6.6679	1	Soo	
BRT 210		20090	+2718	9.6	10.5	26.56	5.417	6.6506	1	Soo	
SEI 919		20090	+3516	10	11	113.61	5.780	6.6679	1	Soo	
BRT2255		20099	+4618	9.5	10.4	251.37	5.333	6.6506	1	Soo	
SEI 938		20101	+3602	11	11	19.91	4.978	6.6679	1	Soo	
SEI 945	AB	20104	+3644	9.5	11	273.73	6.214	6.6679	1	Soo	
ES 1099		20105	+4923	10	11	183.87	6.576	6.6506	1	Soo	
J 1875		20113	+2056	12.19	12.43	99.29	8.810	6.7281	1	Soo	
MLB 530		20115	+2846	9.5	10	30.23	8.251	6.6679	1	Soo	
SEI 968		20115	+3539	9	9.8	127.24	6.131	6.6679	1	Soo	
SEI 969		20115	+3551	9.1	10.8	352.01	8.908	6.6679	1	Soo	
SEI 976		20116	+3621	10.5	11	1.35	8.598	6.6679	1	Soo	
SEI 978		20117	+3600	11	11	150.99	8.134	6.6679	1	Soo	
SEI 983	AB	20119	+3551	10.8	10.8	88.87	3.373	6.6506	1	Soo	
BRT2256		20121	+4402	9.2	9.7	25.49	3.314	6.6506	1	Soo	
J 3057		20123	+2215	10	10.8	101.02	6.562	6.6679	1	Soo	
J 3057		20123	+2215	10.0	10.8	104.73	6.443	6.7281	1	Soo	
AG 250		20129	+3429	8.5	10.3	50.82	8.713	6.6679	1	Soo	
SEI1011		20129	+3642	10.5	11	257.66	7.049	6.6679	1	Soo	
MLB 661		20134	+2941	9.6	10.5	168.02	3.657	6.6506	1	Soo	
SEI1025	AB	20135	+3912	11	11	344.73	6.053	6.6679	1	Soo	
BRT 47	AB	20145	+2808	10.76	10.89	229.74	4.562	6.6506	1	Soo	
ES 2047	BC	20146	+3855	10.1	10.3	198.00	4.243	6.6506	1	Soo	
SEI1040		20146	+3522	10.5	11	47.80	4.371	6.6506	1	Soo	
MLB 982	BC	20151	+3929	10	11	350.48	5.863	6.6506	1	Soo	
BRT2257		20159	+4307	9.8	11	101.28	3.439	6.6506	1	Soo	
ROE 42		20159	+4257	10.6	11	91.58	6.027	6.6679	1	Soo	
MLB 478	AB	20160	+2929	9.5	10	12.87	6.972	6.6679	1	Soo	

Pair	Comp	RA	Cec	V_a	V_b	PA	Sep	2000+	N	Obs	Notes
SEI1050		20162	+3805	11	11	312.84	3.919	6.6506	1	Soo	
J 3071		20173	+2009	12.32	12.29	217.75	5.986	6.6506	1	Soo	
SEI1065		20175	+3205	9.7	10	1.94	3.950	6.6506	1	Soo	
ES 2502		20176	+3806	10.5	11	327.13	5.716	6.6679	1	Soo	
ES 2502		20176	+3806	10.5	11.0	322.60	5.232	6.7308	1	Soo	
SEI1066		20176	+3130	10	10.5	311.39	8.302	6.6679	1	Soo	
MLB 881		20185	+3916	9.3	11	139.25	10.548	6.6679	1	Soo	
SEI1079		20188	+3909	10.5	11	108.60	6.218	6.6679	1	Soo	
J 554		20190	+2131	11.95	11.31	214.72	5.711	6.6506	1	Soo	
J 3074		20190	+2121	9.7	9.9	329.89	7.982	6.6679	1	Soo	
ES 2504		20192	+3822	10.5	11	110.72	8.052	6.6679	1	Soo	
MLB 609	AB	20195	+2740	10	10	280.18	5.191	6.6506	1	Soo	
ES 503		20196	+4807	9.2	9.5	357.91	4.921	6.6506	1	Soo	
POU4375		20199	+2402	10.4	10.9	28.83	8.132	6.6679	1	Soo	
J 3078		20222	+2606	10.2	10.2	23.55	7.076	6.6693	1	Soo	
HJ 1510	AB	20223	+4748	9.4	9.5	146.50	4.330	6.6693	1	Soo	
ES 2506		20226	+3656	10.5	10.7	149.38	6.006	6.6693	1	Soo	
J 3081		20228	+2023	10	11	359.81	6.274	6.6693	1	Soo	
ES 2434		20251	+3141	10.5	10.7	285.78	4.139	6.6693	1	Soo	
BRT2476		20272	+2049	10.4	10.6	76.63	5.875	6.6693	1	Soo	
MLB 662		20281	+2819	9.8	10.2	41.36	3.529	6.6693	1	Soo	
MLB 362		20284	+7015	10	11	22.96	5.450	6.6693	1	Soo	
MLB 532		20287	+2924	10	10.2	343.23	8.999	6.6693	1	Soo	
J 1196		20312	+4137	9.5	10.5	3.71	5.022	6.6693	1	Soo	
BRT2265		20315	+4148	10.4	11	288.08	5.236	6.6693	1	Soo	
SEI1156		20323	+3726	9.5	10.8	88.63	6.347	6.6693	1	Soo	
HJ 1549		20361	+4745	9.6	10.5	57.82	5.548	6.6693	1	Soo	
BRT2267		20362	+4008	10.1	10.7	158.85	4.331	6.6693	1	Soo	
BRT2269		20395	+4002	10.5	10.6	196.16	5.154	6.6693	1	Soo	
ES 1570		20417	+4202	10.7	10.8	116.97	4.639	6.6693	1	Soo	
BRT2271		20420	+4532	10.3	10.6	267.02	4.284	6.6693	1	Soo	
MLB 664		20422	+2852	9.9	9.9	170.23	4.950	6.6693	1	Soo	
BRT2480		20423	+2109	10	10.6	232.62	5.130	6.6693	1	Soo	
MLB 24		20429	+4036	9.5	9.7	172.15	6.016	6.6693	1	Soo	
BRT2273		20431	+4637	9.9	10.3	309.37	4.394	6.6693	1	Soo	
BRT3361		20448	+2500	10.6	10.9	142.53	4.695	6.6693	1	Soo	
BRT 217		20461	+2638	10.8	11	79.95	4.140	6.6693	1	Soo	
ES 2253		20478	+4754	10	10.2	336.23	3.516	6.6693	1	Soo	
HJ 1584		20496	+4805	10	11	224.08	4.426	6.6693	1	Soo	
ES 2378		20503	+3337	10.5	10.8	10.92	6.180	6.6693	1	Soo	
BRT2277		20511	+4224	9.2	10.3	230.05	3.938	6.6693	1	Soo	
ES 2380		20534	+3220	10.7	10.9	332.92	5.776	6.6693	1	Soo	
J 3117		20538	+3029	11	11	40.45	5.295	6.6693	1	Soo	
BRT2280		20539	+4139	10.5	10.6	188.78	5.038	6.6693	1	Soo	
SEI1307		20546	+3709	9.3	11	300.67	4.120	6.6693	1	Soo	
MLB 783		20555	+3940	10	11	292.41	5.673	6.6693	1	Soo	
MLB 573	AB	20579	+2940	10.2	10.3	235.22	5.488	6.6693	1	Soo	
BRT 220		20597	+2418	9.7	9.8	133.86	4.333	6.6693	1	Soo	

AN ANALYSIS OF ERRORS OF THE MEASUREMENT OF VISUAL DOUBLE STARS USING THE CELESTRON MICRO GUIDE WITH AN SCT AND ALT-AZIMUTH MOUNT

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Summary

An analysis has been conducted of the errors incurred in using the Celestron Micro Guide reticle eyepiece to measure visual double stars with a Schmidt-Cassegrain telescope and alt-azimuth mount. Teague's advanced method of measuring drift angles is employed, which is described in detail in the paper. It is shown that, with sufficient measurement replications, position angle can be estimated to $\pm 0^{\circ}.5$ and separation to better than $\pm 0''.4$. Special precautions for the SCT-alt/az combination include the need to re-calibrate the scale constant if the coarse focus of the SCT is changed (for example in doing general observing between double star measurements, or using a Barlow), and the need to correct for field rotation for one particular method of centering the primary in the eyepiece, described in the paper. The error analysis shows that using stars at high declinations give the least error in determining the scale constant (commensurate with a reasonable time of passage along the linear scale). The error in measuring PA decreases with increasing separation. The error in measuring separation has a cyclic dependency, but overall it increases with separation. The measurement of a neglected southern double using the CMG was compared with a measurement made by another observer using a filar micrometer and found to agree to within the calculated limits. It is concluded that the CMG can be used with an SCT and alt-az mount to measure visual double stars to an acceptable accuracy and precision.

Introduction and Objectives

The Celestron Micro Guide (CMG) comprises an orthoscopic eyepiece of 12.5mm focal length with an LED-illuminated laser-etched reticle. It was developed mainly as an aid to guiding for astrophotography and for measuring the separation and position angles of celestial objects. Meade offers a similar product.

Tom Teague, first in Sky and Telescope (2000) and then in Bob Argyle's book 'Observing and Measuring Visual Double Stars' (2004), described an ingenious method of using the CMG for estimating the separation and PA of visual double stars, involving the measurement of drift angles together with a coarse measurement of separation. This appeared to offer the prospect of obtaining measurements of sufficient accuracy and precision for serious work using a relatively cheap and accessible instrument.

The key to making useful measurements with any method is a clear understanding of the source, magnitude and mitigation of measurement error, both random and systematic. There have been few reported analyses of the errors involved in Teague's method (some are discussed below), and as far as the author can ascertain none for the combination of a CMG with an alt-azimuth mounted Schmidt-Cassegrain telescope, which can present special problems depending on how the measurement is actually done. Since this is a common combination for amateur observers, it seems worthwhile to confirm that it can combine with Teague's method to deliver results of acceptable accuracy and precision for serious work.

This paper therefore presents a rigorous error analysis of Teague's method in the alt-azimuth context to determine whether it can produce results of acceptable quality and to determine how accuracy and precision can be maximised in the implementation of the method. All the work described in the paper was undertaken with a Meade

LX200GPS f10 14-inch Schmidt-Cassegrain telescope with alt-azimuth mount and the Meade Autostar II Go-To facility, with no equatorial wedge or field derotator. The telescope is located in an outer suburb of the city of Brisbane in Australia at a latitude of 27° 33′ south, with a naked eye limiting magnitude of about 4.8.

The Method

Teague's 'advanced' method is used here, which is capable of better accuracy than the simple method. The reader is referred to Teague (2000, 2004) for a full description. Fig.1 shows the CMG reticle layout (taken from the CMG manual). In Teague's method, only the linear scale (1) and outer protractor (4) are used.

Determining the Scale Constant

The central linear scale is required to estimate the pair separation, and needs to be calibrated for the particular telescope and eyepiece in use, including a Barlow lens if used. Any change to the telescope effective focal length including addition or removal of a Barlow requires re-calibration. In the SCT optics used here, the coarse focus of the telescope is achieved by moving the mirror itself, changing the focal length. The scale constant must therefore be re-estimated every time that the coarse focus is used, eg after other eyepieces are used for other observing work. In the author's experience the focal length can change over a range of 40mm in a nominal focal length of 3556mm, or about 1%. This corresponds to a difference in scale constant of about 0.06 in a nominal value of about 5.75 in the system used by the author (eqn.1 below - no Barlow). If no change is made to the focal length between double star measurements then the same scale constant can be used.

The calibration is effected by timing the drift of any star of known declination along the scale. The eyepiece is rotated until the star drifts exactly along the scale when the drive is switched off, and the time taken to traverse the 60 divisions is measured using a stop watch. The scale constant C is then given by

$$C = \frac{15.0411 \times t \times cos\delta}{60} \qquad arcseconds \;\; per \;\; division \qquad (1)$$

where δ = declination of the star (degrees) and t = time of drift (seconds)

The constant 15.0411 is the sidereal motion in degrees per hour, and 60 is the number of divisions in the scale.

The linear scale calibration should be made many times on several nights and a mean value taken. Teague's original article (2000) suggests 5–10 times, but his later description (2004) suggests 30 times. A statistical justification for the number of repeats is made later in this paper. It should aslo be noted that field rotation (discussed further below) will cause the star to drift off the linear scale over time. The eypiece will need to be rotated to accommodate this effect.

Note that 'switching off' the Meade DC servo tracking motors involves selecting the Setup > Telescope > Tracking > Custom menu on the Autostar II handbox and then entering -999, which reduces the tracking rate to 0.1% of the normal sidereal rate. A small motion therefore remains; the error incurred is discussed further below.

Measuring Separation and Position Angle

The pair to be measured is then positioned with reference to the central linear scale, as described below, and the drive again switched off so that the stars drift to the west. The angle at which the primary (brightest) star reaches the circumferential 360° protractor scale is recorded, first with the pair aligned along the central scale (θ_0), and then with the eyepiece turned so that the stars fall exactly on two of the scale marks (this is done

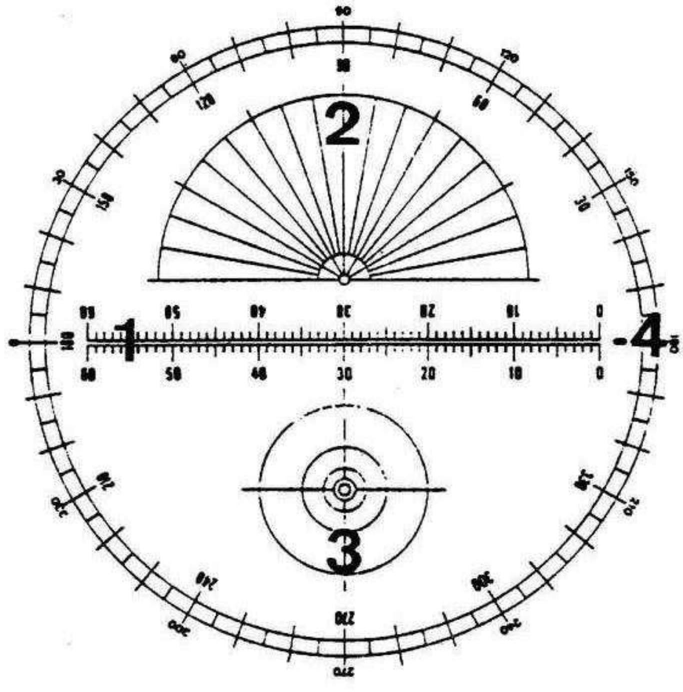

Figure 1: Celestron Micro Guide Reticle

twice, once in each direction: θ_1 and θ_2). The three measured angles are then used to determine the separation and the position angle using simple trigonometry as explained below.

When aligning the pair relative to the linear scale, the primary star is positioned closest to the zero degree point of the inner of the two circumferential protractor scales - the point by the numeral "4" in Figure 1. This ensures an easy calculation of PA. The number of full divisions separating the two stars is then read (n). For example, if the secondary is between 5 and 6 divisions away from the primary, n = 5.

The two stars are now manoeuvred until they lie exactly along the middle of the central scale, by rotating the eyepiece and using the slow motion controls. The primary is then moved to the centre of the scale between the two "30" numerals and the drive switched off. The pair will drift west (PA 270°). When the primary crosses the inner of the two circumferential protractor scales the angle is read and recorded (θ_0).

The 'Sidereal' tracking mode is then selected (normal tracking rate) and the slow motion controls are used to bring the pair back to the central scale. The eyepiece is then rotated either clockwise or anticlockwise until the pair exactly bisects any two divisions n divisions apart. As before, the primary is then moved to the centre of the scale, the drive switched off, and the angle at which the star crosses the protractor scale noted (θ_1). The pair is then returned to the central scale, and the process repeated after turning the eyepiece in the other direction (θ_2).

In practice because of small tracking errors it is often difficult to keep the primary exactly at the centre of the scale for the time required to 'switch off' the drive by going through Autostar's menus, which may be several seconds. It is therefore sometimes easier to switch off the drive and then use the slow motion controls to manoeuvre the primary so that it drifts through the exact centre of the scale. With practice this is a surprisingly effective method, and was the one used in the present work. The impact of field rotation on this 'dead time' is discussed below.

We now have four measurements for the pair - n, θ_0, θ_1 and θ_2 - plus the scale constant C. The PA and separation are calculated from the following formulae:

$$Separation \quad \rho = \frac{nC}{cos((\theta_2 - \theta_1)/2)} \quad arc \;\; seconds \tag{2}$$

$$PositionAngle \quad \theta = \frac{(\theta_0 + \theta_1 + \theta_2)}{3} + 90 \quad degrees \quad (3)$$

Note that in Argyle (2004) Teague describes the measurement of PA using only θ_1 and θ_2 (divided by 2) but then in his Table 12.3 shows an example including θ_0 and using eqn.3. θ_0 (+90°) is in fact a direct measure of the PA of the pair. Since it is easier to judge alignments when aligning the pair along the central scale than when matching them to n divisions, the standard deviation of θ_0 is generally lower than those of the other two angles. The inclusion of θ_0 will therefore improve the precision of the measurement and is the method followed here.

The Trigonometry

Teague's method is simple but effective. Fig.2 shows the measurement for a pair for which the PA is exactly 270° , *i.e.* the secondary is due west of the primary, the direction in which the stars drift when the drive is off. (This makes the demonstration easier. In Fig.2, if the PA is not 270° the arc along which the eyepiece is turned will not be symmetrical about the centre line but will be displaced to one or other side). In this example n = 3, *i.e.* the pair lies between 3 and 4 divisions apart. Rotating the eyepiece about the primary in each direction effectively moves the secondary along the arc shown, which is part of a circle whose centre is at the primary and whose radius is d, the separation of the pair. This generates a right-angle triangle with two sides of length d and n and an included angle α which is the angle through which the eyepiece must be turned to bring the two stars exactly in line with two reticle lines n divisions apart. Simple trigonometry then gives the desired separation:

$$d = \left(\frac{n}{cos\alpha}\right) \quad (4)$$

In fact α is calculated as half the *total* angle through which the eyepiece is rotated over the two rotations, (θ_2 - θ_1)/2, giving effectively the mean of two replicate measurements. After multiplying this estimate by the scale constant, C, we obtain eqn.2 for the estimate of d in arcseconds.

As noted above, the PA can be estimated directly by letting one of the stars drift west after aligning them along the central scale. In Fig.2 the pair would drift exactly along the scale, giving θ_0 = 180° , *i.e.* PA = 180° + 90° = 270° . However the mean of the other two angles, θ_2 and θ_1, gives another independent estimate of θ_0. So a better overall estimate of the angle of drift is $(\theta_0 + \theta_2 + \theta_1)/3$, and the PA is then given by eqn.3.

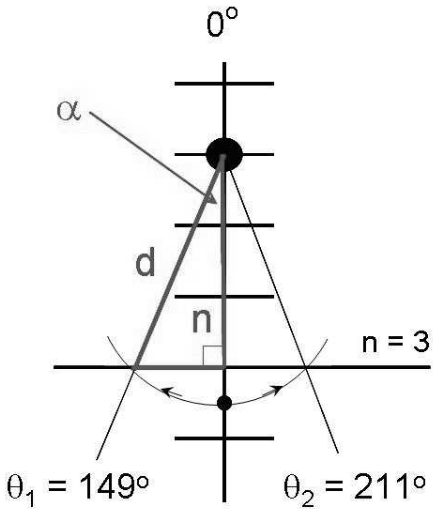

Figure 2: Teague's method

Previous Work

There has been little published work on errors with the CMG, and none specifically for an alt-azimuth mount. Teague in his original article (Teague, 2000) points out, correctly, that the error in separation increases with the angle (θ_2 - θ_1)/2 (though see Fig. 7 below). He states that PA should be measurable to within 2° , and separation to ±5% or better for separations up to 10″ and ±3% for wider pairs. The standard deviations from 4 repeats quoted by Teague in Argyle's book (Teague, 2004) were 0°.73 and 0″.24 for PA and separation respectively, using an 8.5-inch Newtonian reflector on an equatorial mount, and with angles estimated to 0°.5.

Garcia (see web address) used error propagation theory to explore errors in the scale constant, C, and the measures of separation and PA. He quotes an uncertainty of ±0″.016 per div in estimating a scale constant of 4.29, ±1″.2 in measuring a separation of 34″.3 and ±1°.7 in measuring a PA of 230° for a close separation (*i.e.* a difficult measurement).

Harshaw (2002) organised an observational programme with eight observers using telescopes ranging from a 2.5-inch refractor to an 11-inch SCT, in which the observed PAs and separations were compared with tabulated WDS values for a variety of pairs. Each recorded value was the mean of between 1 and 10 repeated measures. The difference in observed and tabulated values was defined as an error, though this assumes that the WDS value is absolutely correct, and the deviation from it reflects some imperfection in the observer's measurement. These deviations may not have the generally accepted properties of random error. Phase II of the programme involved the observation of pairs which had shown no significant movement for at least 50 years. Phase III involved further measures of both 'fixed' and varying pairs. The root mean square 'errors' for separation and PA in Phase II were 0″.6 and 1°.1 respectively (present author's calculation). There was evidence for increased 'error' in PA at low separations, and decreased 'error' for both PA and separation with increasing replication. Harshaw concluded that close pairs are difficult to measure due to the short baseline available for aligning the central scale for the PA measurement, and pointed out some practical issues involved in using the CMG in this application.

An Error Analysis

There are four original measurements from which the PA and separation are determined: the time of drift in estimating the scale constant, and the three angles. A little thought will show that there are several potential sources of error in making these measurements. As in all measurement systems, they can be classified three ways: the instrument limit of error (*e.g.* the precision of the stop watch, or the precision with which the protractor scale can be read), random errors and systematic errors. It is helpful to be able to understand the relative contributions of these various sources of error both to estimate the overall error of measurement and to suggest refinements to the method to improve accuracy and precision. The usual methods of error analysis can be applied for this purpose.

The Scale Constant

In measuring astronomical events, the skill of the operator (in this case timing the passage of the star across the first and last lines of the central scale) is called the personal equation, and is here due to the systematic delay in operating a stop watch. As the duration of the passage of the star is determined from a difference in two times, the personal equation cancels and should play no role in error.

The theory of error propagation can be used to estimate the error in C as a function of the random measurement errors in t (the time of passage of the star along the scale) and δ (the declination of the star). The theory gives:

$$\Delta C = \frac{\partial C}{\partial t}\Delta t + \frac{\partial C}{\partial \delta}\Delta\delta \qquad (5)$$

where Δ signifies 'error in', best interpreted as the maximum deviation likely from the true value due to random effects or the precision of reading a scale. The validity of eqn.5 requires that Δt and $\Delta\delta$ are small, random and independent. Applying this to eqn.1 gives:

$$\Delta C = 0.251(cos\delta \times \Delta t + tsin\delta \times \Delta\delta) \qquad (6)$$

Δt here is taken to be (conservatively) 0.2 s. Garcia (see web address) in a similar analysis suggested that $\Delta\delta$ should be taken as the uncertainty of declinations given in the Tycho 2 catalogue which he quotes as 25×10^{-3} arcseconds = 6.94×10^{-6} degrees. For a star of declination (-)60° and t = 60 s (a typical value for the present optical system), eqn.6 gives $\Delta C = 0.0252$ arcseconds per division. For $\delta =$ (-)75° , $\Delta C = 0.0131$ arcseconds per division. For a scale constant of about 5.75, as in the present case, these errors are 0.4% and 0.2% of the mean respectively.

Eqn.6 can be used to estimate the relative contributions of the errors Δt and $\Delta\delta$ to ΔC. In both examples above the contribution of $\Delta\delta$ is less than 1% of the total. The error in the scale constant is therefore dominated by the absolute value of the declination of the test star and the error in estimating the time. Higher declinations give lower overall errors because cos δ decreases as δ increases; the reverse effect of sin δ is negated by the very small value of $\Delta\delta$. Teague (2004) suggests choosing " ...a star of relatively high declination, but without straying too close to the celestial pole" which on this analysis is good advice. He finds that a declination of between 60° and 75° is suitable. The larger the declination, of course, the longer will be the time of the passage of the star along the scale, and therefore the largest declination should be chosen commensurate with a reasonable time of passage.

Star catalogues give declinations for a given epoch, e.g. 2000. A further potential error arises when the date of measurement is significantly different from the epoch of the given value of δ. This is a systematic not random error and cannot be included in eqn.5. Where the declination at the date of measurement is available (eg from a planetarium program such as CARTES DU CIEL used by the author) then the actual declination can be used. Where this is not so, the effect of precession should be considered. This will depend upon the right ascension of the star, and the time elapsed between the epoch date and the date of measurement. The error will vary from zero for stars with RA 6h and 18h to $3'.3$ in 10 years for stars with RA 0h and 12h (Ridpath, 1998). This represents a maximum error in calculating the scale constant from eqn.1 of about 0.01 arcs/div after 10 years, which is negligible. Using the 1950 Epoch in 2006, however, could incur an error as high as 0.1 arcs/div which is not negligible. It is a simple matter to obtain current declinations and this should be done.

Another way to look at the error in scale constant is to assume that the final estimate (C) is a random variable and then determine its standard deviation by repeated measures. Table 1 shows the results of many such measurements by the author of four stars over a period of four months, including the effects of changed focus from month to month and thus changed scale constant. Within each 'monthly' mean, there was no change in focus, so each standard deviation represents random variation only.

The overall weighted standard deviation was 0.0215 arcs/div, which is of the same order as the 'maximum error' obtained from eqn.6. (The overall weighted standard deviation of time measurements was 0.228s which agrees well with Garcia's value of 0.206 for one set of 20 repeats). Note that the range of mean values 5.73 – 5.80 reflects real differences in focal length as the telescope was re-focussed for use in general observing between monthly double star use. The 2-sample t-test was used to show that these differences were statistically significant with >99% confidence in most cases (the exception being the two zeta Hydri means).

Table 1 - Replications of measurement of scale constant for four stars

Star	alpha TrA		kappa TrA		
Declination	-69°.043		-68°.619		
Month (2005)	Aug	Sep	Oct	Aug	Sep
No. of results	20	20	22	21	10
Mean C (arcs/div)	5.797	5.747	5.759	5.778	5.760
Std. Deviation	0.0198	0.0257	0.0198	0.0164	0.0192

Star	upsilon Pav		zeta Hyi		
Declination	-66°.740		-67°.592		
Month (2005)	Aug	Sep	Oct	Oct	Nov
No. of results	17	30	10	24	20
Mean C (arcs/div)	5.786	5.759	5.734	5.740	5.730
Std. Deviation	0.0230	0.0201	0.0288	0.0185	0.0255

One would expect the repeated measures to be normally distributed and this is indeed the case. Fig.3 shows a normal probability plot for the 30 repeats of Ups Pav Sept. The data follow a straight line well, and the Anderson-Darling statistical test supports the hypothesis of normality. The other datasets showed similar features.

The standard deviation can be used to calculate the number of repeat measurements needed to estimate C to a given confidence, using simple statistical theory:

$$N = \left(\frac{z\sigma}{E}\right)^2 \qquad (7)$$

where N is the number of observations required to determine the value to within $\pm$ an error bound E, at a confidence level defined by the normal ordinate z, and σ is the measurement standard deviation. z is 1.96 for 95% confidence. Fig.4 shows how the error depends on the number of observations using eqn.7, for a standard deviation of 0.0215.

Fig.4 suggests that about 20 repeats are needed to estimate C to within 0.01 arcseconds/ division with 95% confidence. 10 repeats will produce an estimate within 0.013 arcs/div. Clearly these values will change for different prevailing standard deviations. Teague (2004) suggests at least 30 repeats be taken over several nights which on this analysis is more than enough.

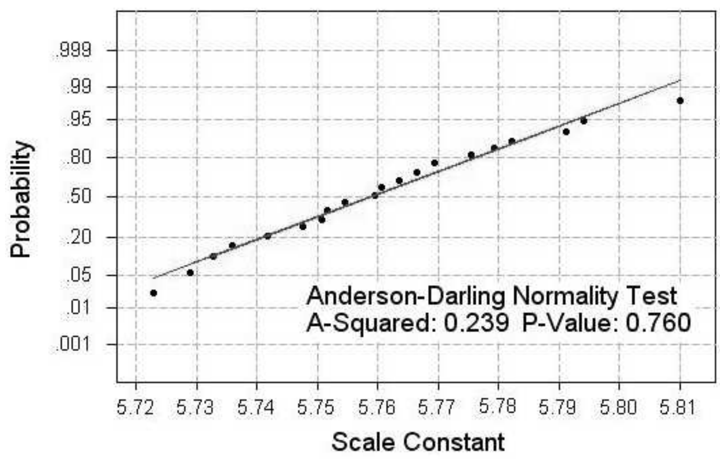

Figure 3: Normal probability plot for replicates of the scale constant: Ups Pav Sept. 2005.

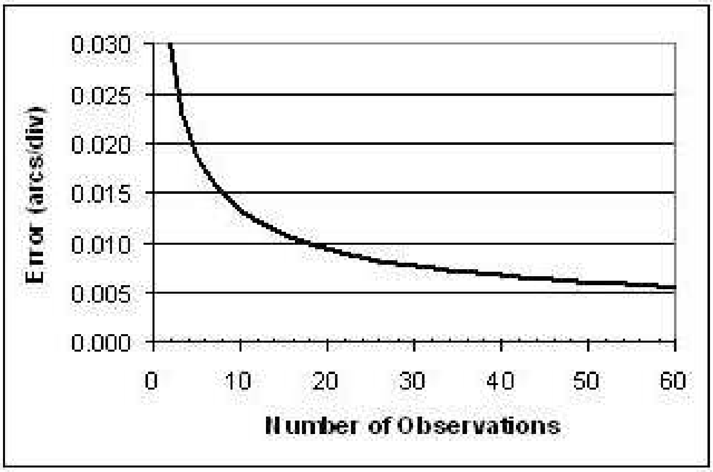

Figure 4: Error in estimating scale constant vs number of observations (std.dev. = 0.0215)

The Effect of Field Rotation on the Measurement of Angles

As pointed out by Greaney (2002), an alt-azimuth mounted telescope will experience field rotation as it tracks the sky at the sidereal rate, and this can affect the measurement of double stars. In this case the field rotation which matters is that which occurs between the moment at which the two stars are aligned on the linear scale and the moment at which the primary passes the centre of the scale with the drive switched off, when the drift commences. The process described earlier of switching off the drive and then manoeuvring the pair to allow the primary to pass through the centre of the scale can take over 1 minute in extreme cases but averages about 30 seconds. If field rotation over this period is significant, then a correction may be needed as the final angle recorded will have moved slightly by the time the star starts the drift period.

As Greaney points out, field rotation peaks as a star crosses the meridian and is greater the closer it is to the zenith. At the zenith rotation is essentially infinite and there is a spherical cap around the zenith where rotation is too great to make meaningful measurements. Rotation is zero when the star is on the prime vertical, *i.e* due east or west. So the best time to make the measurements is when the star is in the eastern or western regions of the sky, rather than due south or north. Greaney (2002) provides formulae to calculate field rotation rates (though there are errors in the published book) and software to make the calculations (which operates correctly).

No correction for field rotation is necessary in applying eqn.2 to calculate the separation. If the durations between aligning the pair on the scale and starting the drift are equal for the two angles the errors cancel completely. Even if they are not, the net error will always be small. In one case in which measurements were made with a large prevailing field rotation of about 40 deg/h with varying durations, the net correction to the calculated mean separation was $0''.01$ which is negligible.

In the case of PA the situation is different. In applying eqn.3, field rotation produces a systematic error in the values of θ_0, θ_1, and θ_2. The correction required to the term $(\theta_0 + \theta_1 + \theta_2)$ in eqn.3 is:

$$\pm(t_0 R_0 + t_1 R_1 + t_2 R_2)/3600 \qquad \textit{degrees} \qquad (8)$$

where t_i = manoeuvring duration for measurement of θ_i (secs) and R_i = rotation rate during the manoeuvring period (deg/h), determined from Greaney's software. To calculate the correction, the manoeuvring duration must be measured by starting a stopwatch when the pair is aligned on the linear scale and stopping it when the primary passes through the centre of the scale.

The rotation rate in deg/h is positive south of the prime vertical and negative north of the prime vertical (in the southern hemisphere). The angle measured in the CMG will be too high when the rotation rate is positive and too low when it is negative, and the absolute correction must therefore be subtracted or added respectively. If the computed sign of R in eqn.8 is preserved then the correction is always subtracted.

In measuring five doubles as part of this study, the absolute correction per angle measured ranged from zero to 0°.68 with a mean of 0°.2.

(If the pair can be aligned along the scale with the primary at the centre of the scale, and the drive then immediately switched off to allow drift, no correction is required as no rotation will have occurred. Also field rotation does not occur with a correctly aligned equatorially mounted telescope and no correction is required for such telescopes.)

Greaney's formula can also be used to determine the effect of the Meade LX200GPS system for 'switching off' the drive motors, which as noted earlier actually reduces the tracking rate to 0.1% of the sidereal rate rather than zero. If the tracking rate is not zero, rotation will have occurred in the time between the primary leaving the central linear scale and reaching the protractor scale, resulting in a systematic error in estimating the resulting angle. Following the general argument above, the error in the angle will be tR. t, the duration of drift, will vary with the position of the pair in the sky but 20 seconds is a typical value. The highest rotation rate encountered in the present work was about 40 deg/h. The error in this case will equal $0.0001 \times 20 \times 40/3600 = 2 \text{ x } 10^{-5}$ degree, which is negligible and can be ignored.

The Position Angle

If the precision in reading the angle on the CMG protractor were the only error in determining the position angle, θ, then applying the theory of error propagation to eqn.3 gives:

$$\Delta\theta = \frac{\partial\theta}{\partial\theta_0}\Delta\theta_0 + \frac{\partial\theta}{\partial\theta_1}\Delta\theta_1 + \frac{\partial\theta}{\partial\theta_2}\Delta\theta_2 \qquad (9)$$

and

$$\Delta\theta = \frac{\Delta\theta_0 + \Delta\theta_1 + \Delta\theta_2}{3} \qquad (10)$$

We assume that $\Delta\theta_0 = \Delta\theta_1 = \Delta\theta_2$. The maximum error in PA would therefore be equal to the precision in reading the protractor. The scale is marked in divisions of 5° and with practice it is easy to read the scale to 0°.5. This author attempts to estimate the readings to 0°.1 but the true precision after considerable practice is probably in the range 0°.2 – 0°.5, which in this simple interpretation is therefore the error in determining PA.

However there are two other sources of error: the alignment of the pair either along the central scale or to coincide exactly with two divisions, and the positioning of one of the stars at exactly the centre of the scale before allowing it to drift to the outer protractor. These are both random errors, and the final estimate of PA will include all three sources. The best way to estimate the overall error is therefore by repeated measure, using the confidence interval determined from the sample.

Table 2 shows the mean PAs, standard deviations, number of observations and 95% 2-sided confidence interval ($ts/\sqrt(n)$) for five doubles measured as part of this programme. The doubles were measured over a number of nights with several repeats per night, with no Barlow. The confidence intervals are in the range ±0°.4–1°.05 with an average of ±0°.66. This is therefore the order of precision which can be expected in using this method, and is of the same order as that calculated from the simple theory above. The example given by Teague (2004, p.156) with 4 repeats had a standard deviation of 0°.73.

As with the case of the scale constant, eqn.7 can be used to construct a curve showing the relationship between the number of observations required and the error, for a given standard deviation. Fig. 5 shows such a curve for the mean standard deviation of 1°.2. Fig.5 suggests that about 22 repeats are needed to estimate PA to within 0°.5 with 95% confidence. 6 repeats will produce an estimate within 1°. Clearly these values will change for different prevailing standard deviations.

Table 2 - Replications of measurement of PA for five stars

Star	PA	Std. Dev.	N	95% conf. interval ±°
theta Pic	287.7	1.06	20	0.50
theta Eri	90.6	1.53	20	0.72
BSO16 Vol	209.7	0.63	12	0.40
HJ4122 Vel	155.7	1.90	15	1.05
BU1064 Pup	256.3	1.00	12	0.64

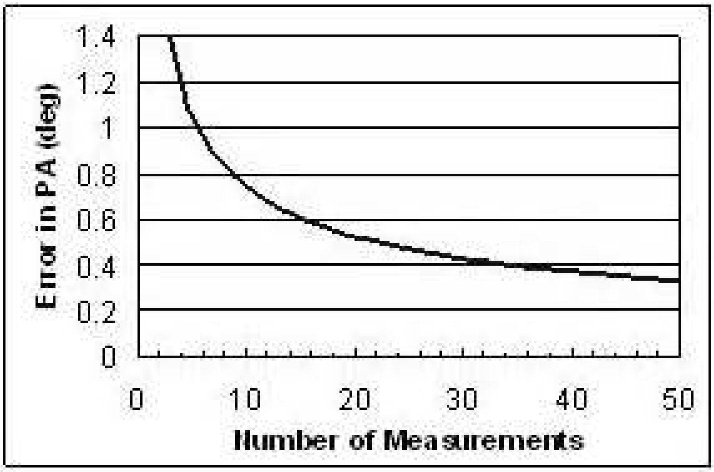

Figure 5: Error in estimating PA vs number of observations (std.dev. = 1.2)

The Separation

In eqn.2 for the estimation of the separation, n is counted without error. The scale constant, C, and the two angles, θ_1 and θ_2, are subject to random errors, and as before the theory of error propagation gives:

$$\Delta\rho = \frac{\partial\rho}{\partial C}\Delta C + \frac{\partial\rho}{\partial\theta_1}\Delta\theta_1 + \frac{\partial\rho}{\partial\theta_2}\Delta\theta_2 \qquad (11)$$

Applying this to eqn.2 and ignoring signs gives:

$$\Delta\rho = \frac{n}{cos((\theta_1-\theta_2)/2)}\Delta C + \frac{1}{2}\left(\frac{nCsin((\theta_1-\theta_2)/2)}{cos^2\ ((\theta_1-\theta_2)/2)}\right)\Delta\theta_1 + \frac{1}{2}\left(\frac{nCsin((\theta_1-\theta_2)/2)}{cos^2\ ((\theta_1-\theta_2)/2)}\right)\Delta\theta_2 \qquad (12)$$

$\Delta\rho$, the uncertainty in the estimate of separation, is therefore a strong function of the term $\frac{1}{2}(\theta_1-\theta_2)$. This leads to an interesting result because this term varies cyclically with n, the number of whole divisions of the linear scale, as shown in Fig. 6. The figure was calculated from the relation $\frac{1}{2}(\theta_1-\theta_2) = cos^{-1}(nC/\rho)$, remembering that the calculation must re-start at every new integer value of n as the separation increases.

$\Delta\rho$ also increases with n and thus with ρ, the calculated separation. The net result of these trends is shown in Fig. 7 which plots the error in the estimate of separation, for particular values of C and errors in C and θ (all angles calculated in radians). The errors are taken to be the 95% confidence limits for around 20 repeats determined from Figs. 4 and 5: $\Delta C = 0''.01$/div and $\Delta\theta = 0°.5$.

The magnitude of error for the 'typical' conditions of Fig.7 is in the range 0″.1–0″.4. It can be seen that the error increases overall with the separation, and also varies considerably within each value of n; its highest value for $n = 1$ is more than its lowest value for $n = 11$. The smallest errors occur at low values of n (and thus ρ) and at

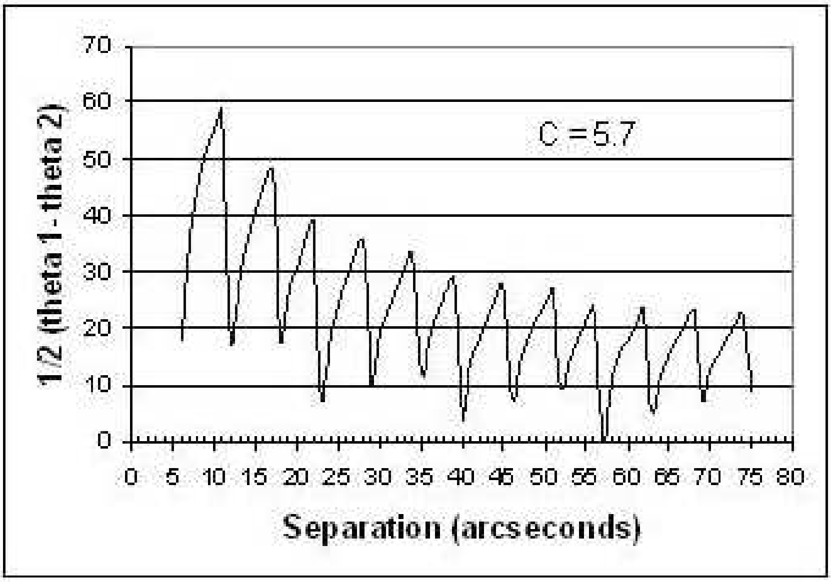

Figure 6: $\frac{1}{2}(\theta_1 - \theta_2)$ term versus separation, for $C = 5.7$.

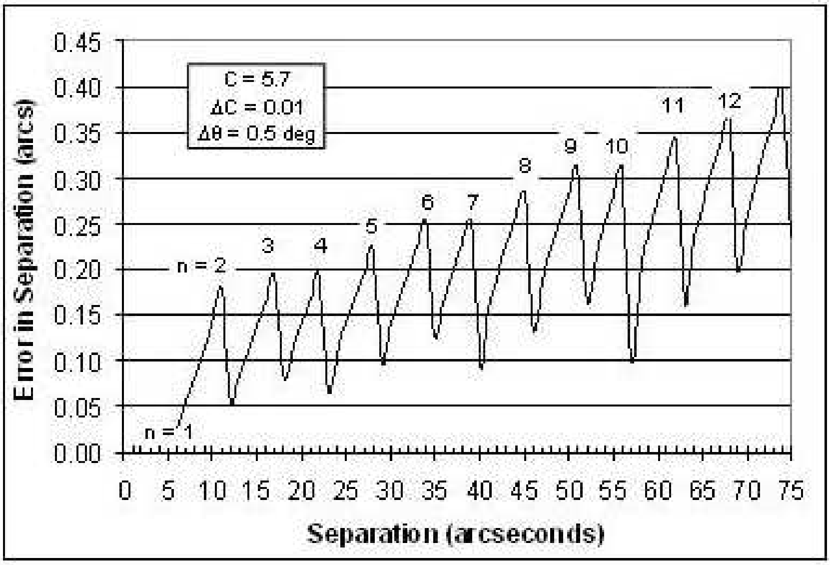

Figure 7: Error in separation vs separation, for $C = 5.7$, $\Delta\theta = 0.5$, ΔC = 0.01

separations just exceeding each integral value of n. The maximum error doubles from n = 2 to n = 12.

Eqn.12 can be used to calculate the contribution of each of the three sources of error (C,θ_1 and θ_2) to overall error. Again it follows a cyclic pattern, with the scale constant, C, contributing most at integral values of n and then declining as the next integral value is approached. Overall, C contributes about a third of the total error and θ_1 and θ_2 jointly two-thirds.

The use of a Barlow lens to increase the apparent separation of a pair is problematical. Eqn.12 shows that the error in estimating the separation increases directly with n, and thus the use of a Barlow will, rather surprisingly, increase the error. Against this, eqn.6 suggests that the error in estimating C , the scale constant, will reduce as the time of passage will reduce. More importantly, experience shows that it is harder to achieve accurate alignment with scale divisions where n is small, which is probably the main cause of the observed increase in PA error at small separations (see Fig.10 below). Inspection of Figs. 7 and 10 suggests that an appropriate compromise is to use a Barlow where n is 3 or less, but otherwise to avoid doing so.

As before, we can think of the separation as a random variable and use replicates to estimate the standard deviation and confidence limits. Table 3 shows these statistics for the same five stars as used for the PA estimates in Table 2. The standard deviations are quite consistent in the range $0''.3 - 0''.6$ with corresponding 95% confidence limits of $\pm 0''.2 - 0''.4$, of the same order as the errors estimated from error theory. The example given by Teague (2004, p.156) with 4 repeats had a standard deviation of $0''.24$.

As before, eqn.7 can be used to construct a curve showing the relationship between the number of observations required and the error, for a given standard deviation. Fig. 8 shows such a curve for the mean standard deviation of $0''.41$, which suggests that about 17 repeats are needed to estimate separation to within $0''.2$ with 95% confidence.

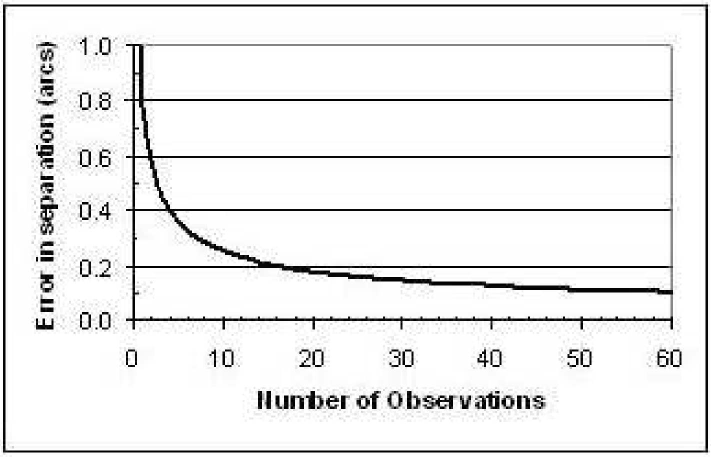

Figure 8: Error in estimating separation vs number of observations (std.dev. = $0''.41$)

Table 3 also provides empirical evidence for the increase in error with separation expected from the earlier theoretical analysis. Fig.9 shows the standard deviation as a function of measured separation for the five test doubles.

The Connection Between PA Error and Separation

One aspect not taken into account in this analysis is the dependence of errors in PA on the actual separation. As pointed out above, it is harder to align the pair along the central scale and bisect the pair n divisions apart when the separation (*i.e.* n) is small than when it is large. This effect is difficult to treat analytically but can be evaluated empirically. Fig.10 shows the relationship between the standard deviation of the PA measurement and the measured separation for the five test doubles, with a fitted exponential curve. Although the data are sparse, the trend is clear, with the standard deviation increasing sharply at separations close to $n = 1$.

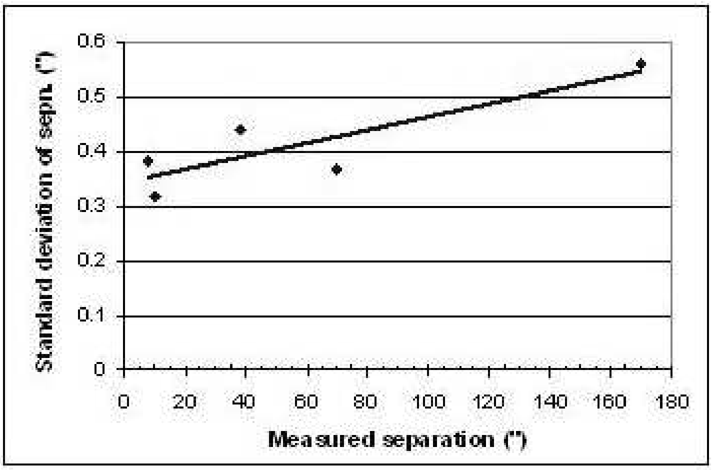

Figure 9: Standard deviation of separation vs separation for five measured doubles

Table 3 - Replications of measurement of separation for five stars

Star	Sepn. (″)	Std. Dev. (″)	n	95% conf. interval ±″
theta Pic	38.2	0.44	20	0.21
theta Eri	8.1	0.38	20	0.18
BSO16 Vol	169.6	0.56	12	0.36
HJ4122 Vel	9.9	0.32	15	0.18
BU1064 Pup	69.7	0.37	12	0.23

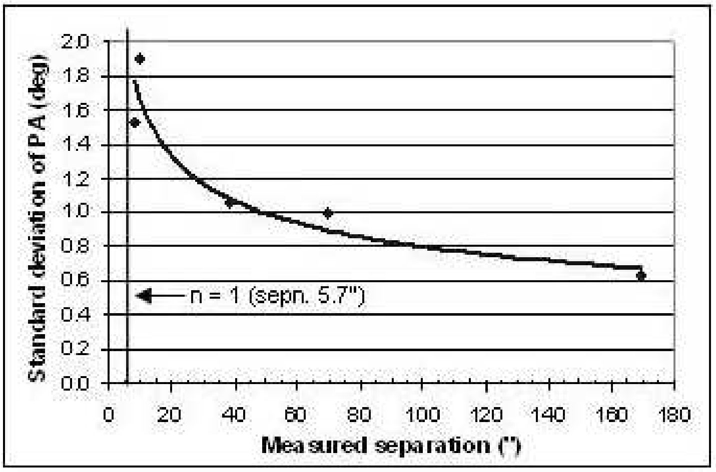

Figure 10: Standard deviation of PA vs separation for five measured doubles

This observation conforms to that of Garcia (Garcia J.F.; see web address), whose assessment of Harshaw's Phase II programme also suggested similar results (Harshaw, 2002).

The Measurement of a Neglected Double - BU 1064

In a final test of the CMG-SCT combination, the author used the methods described in this paper to measure a southern neglected double (BU 1064AD in Puppis) suggested by Bob Argyle of the Webb Society, who kindly observed the same star from the UK using a filar micrometer. The results of both observations, plus those of the last 1899 measure, are shown in Table 4. The ± figures for the author (TJNM) and Argyle (RWA) are the standard deviations of multiple measures (12 in the case of TJNM).

Table 4 - Measurement of neglected southern double BU 1064AD

Observer	year	Separation(″)	PA(°)
AD	1899	60.6	276
TJNM	2006.22	69.7 ± 0.37	256± 1.00
RWA	2006.26	69.4 ± 0.1	257.1± 0.50

The filar micrometer in the hands of a skilled observer clearly gives a more reproducible result than the CMG in this case. However the standard deviations of the CMG measurement are still satisfactory, especially when considering the 95% confidence limits of the 12 repeats: $\pm 0''.23$ and $\pm 0^{\circ}.64$ for separation and PA respectively. The two measures, TJNM and RWA, are not statistically different. The new observations show clear change in both separation and PA.

Conclusion - Errors in Estimating Separation and Position Angle

The CMG with an alt-azimuth mount can be used, with care, to measure visual double stars to a precision and accuracy suitable for serious work. Position angle can be estimated to around ± 0°.50 and separation to better than ± 0″.4. These uncertainties can be reduced by increasing the number of repeat measurements. At least 10 should be performed, and preferably 20.

The scale constant can be determined to ±0.01 arcseconds/division (about 0.2% of the mean in the present case) if sufficient repeats measurements (about 20) are made over several nights. Most of the error comes from the absolute declination of the calibration star. Stars at high declinations give the least error though incur longer passage times along the central scale. A systematic error (though not usually a large one) is introduced if the tabulated declination is not for the current epoch, so the current epoch should be used.

If the only error in estimating PA was the precision of reading the protractor scale for the three angles (0°.5 or better with practice), then the error in the PA is equal to this precision. Treating PA as a random variable to incorporate other errors such as aligning the pair along the linear scale or across two divisions, and manoeuvring the primary to the centre of the linear scale, gives a similar error of ±0.5 if about 20 repeats are made. The error increases at low values of separation. If the drive is switched off and the slow motion controls used to manoeuvre the primary star to the centre of the linear scale before allowing it to drift (as in the present work), then Greaney's correction for field rotation during the manoeuvring period should be applied to the calculation of PA.

The error in estimating separation is a cyclic function of the integer number of scale divisions of separation, and also increases overall with separation. The error in the scale constant contributes about one third of the error and the two angles θ_1 and θ_2 the other two thirds, so minimising errors in calibrating the scale constant is important. The calculated error was in the range 0″.2 – 0″.4 for the conditions studied. Treating the estimate as a random variable suggests that 20 repeats will estimate separation to better than 0″.2.

Comments on Using the CMG

Using the full procedure described in the paper, one estimate of the separation and PA of a double requires the recording of six pieces of information: three angles, and three times (for the correction for field rotation), in addition to the scale constant which remains constant unless the coarse focus has been changed or a Barlow introduced or removed. The time required to make these measurements varies with the declination of the pair (and thus the drift time) and with imponderables such as the times required to align the pair along the linear scale, bisect the two divisions, and bring the primary to the centre of the linear scale prior to drift. Experience shows that the total time required to acquire the measurements needed for one estimate of separation and PA is about 10 minutes, assuming no interruptions or unexpected difficulties. 10 independent measures of the pair therefore require about 1 hour 40 minutes at the telescope, and 20 measures twice this. It is best to spread these over several nights of observing to average out other effects.

The error analysis suggests that a Barlow should be used only in cases where $n \leq 3$. The magnitude limit of the CMG - telescope combination is governed by the dimmest secondary which can be seen against the markings of the central linear scale. With the f10 14-inch SCT used in the present case, the practical limit is about magnitude 10.

The layout of the CMG reticle is not ideal for double star work. Neither the semicircular PA scale nor the concentric guiding circles (items 2 and 3 in Fig.1) are necessary, and make it harder to monitor the primary as it moves across the field towards the circumferential protractor scale, though this is not a serious flaw. It would help to have the protractor scale marked in divisions of 1° rather than 5° , and it would be easier to achieve alignment of the pair exactly an integer number of divisions apart when rotating the eyepiece if the divisions were marked with longer lines. Finally, placing the primary at the centre of the linear scale would be easier if the centre was marked with a circle in which the primary could be positioned or allowed to pass through.

References

Garcia, Jose Fernandez. Determination of uncertainties on the Micro-Guide use.
`http://www.luzestelar.com/Astro/Articulos/en/MicroGuide.htm`

Greaney, Michael. 2004. Some useful formulae. Ch.22 of 'Observing and measuring visual double stars', ed. Bob Argyle, Springer.

Harshaw, Richard. 2002. An investigation of the Celestron Micro Guide illuminated reticle eyepiece as an instrument for measuring double stars. Webb Society Deep Sky Observer, **128**, 1-6.

Ridpath, Ian (Ed.), 1998. Norton's star atlas and reference handbook. 19th ed., Prentice Hall.

Teague, Tom. 2000. Double-star measurement made easy. Sky and Telescope, July, pp.112-117.

Teague, Tom. 2004. Simple techniques of measurement. Ch.12 of 'Observing and measuring visual double stars', ed. Bob Argyle, Springer.

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The author would like to acknowledge the encouragement, help and advice of Bob Argyle, Michael Greaney and Dick Harshaw in exploring the vagaries of the CMG and the world of double star measurement, and Bill Whiten for checking some of his mathematics. His AAQ colleague Graeme Jenkinson supplied the CMG used in this work.

MEASURES OF 1027 NEGLECTED VISUAL DOUBLE STARS

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Introduction

This second series of measurements includes the revision of 1027 neglected and wide anonymous pairs made at Garraf Astronomical Observatory (OAG) which is located in the Garraf National Park, about 30 km south of Barcelona.

The measures of Neglected Visual Double Stars from the USNO/WDS Lists have been made from digitized plates (1970-1990) made with the UK Schmidt Telescope in Australia and the Oschin Schmidt telescope on Palomar Mountain, California, USA. The determination of values of angular separation and position angle are made using astrometric software with a precision of $0''.06$ and $0°.5$ respectively, broadly comparable with micrometric and electronic measurements. The RA and Declination of components is based on the GSC/Tycho-1 astrometric data. In the OAG Supplements the original data, identification of components (from HIP, SAO, GSC and other catalogues) and notes are available too.

The following pages contain Supplements 8-14 to the OAG General Catalogue which have so far been available only in electronic format (see, for instance, the WDS webpage). The first seven Supplements were published in DSSC13([1]). All these pairs have been taken from the WDS Neglected Doubles Southern and Northern List 1/2001. We are currently working on the Middle List 1/2001.

This list also includes 91 anonymous southern pairs which were found in a pilot survey carried out at OAG for wide pairs under 30″ separation and also includes a number of anonymous pairs in the northern hemisphere which were found whilst measuring pairs from the neglected list. Many pairs are new and uncatalogued and these have been notified to the WDS group at USNO and checked by Dr. Brian Mason and his staff. Actually there are 231 pairs with official TOB code (TOB = T. Tobal).

Acknowledgements

I am extremely grateful to Dr. Brian Mason and his colleagues at USNO, for his accurate revision of measurements and the electronic publication on the WDS web site, and to Bob Argyle of the Webb Society, for his support in this definitive compilation and publication of my measures.

Table 1 - pairs by discovery code

WDS CODE	Total	Northern	Southern	WDS CODE	Total	Northern	Southern
A	8	8	0	ABH	10	8	2
AG	21	21	0	ALI	1	1	0
ARA	4	1	3	ARG	10	7	3
B	17	0	17	BAR	1	1	0
BKO	2	2	0	BLL	5	5	0
BSO	5	0	5	BU	37	31	6
BUP	27	27	0	CHE	71	71	0
COO	33	0	33	COU	2	2	0
CPD	3	0	3	CPO	16	0	16
CTT	3	3	0	D	2	2	0
DOB	2	2	0	DON	1	0	1
DOO	3	3	0	DUN	11	0	11
ENG	10	10	0	ES	68	68	0
FAB	5	3	2	FIN	2	0	2
FOX	8	8	0	FUR	1	1	0
GLI	4	4	0	GLP	4	3	1
GYL	27	27	0	H	10	6	4
HLD	2	1	1	HDO	3	0	3
HDS	8	2	6	HJ	327	177	150
HLM	3	3	0	HO	12	10	2
HRG	4	0	4	HU	6	4	2
HWE	2	0	2	HZG	2	2	0
I	15	0	15	J	7	5	2
JC	1	0	1	LDS	1	1	0
JSP	9	0	9	KOP	1	1	0
KU	13	13	0	KUI	1	1	0
KZA	102	102	0	LDS	7	1	6
LPO	12	0	12	MLB	37	37	0
NZO	5	0	5	ODE	2	2	0
OLI	1	1	0	OPI	5	5	0

WDS CODE	Total	Northern	Southern	WDS CODE	Total	Northern	Southern
OSB	2	2	0	PEL	1	0	1
PHL	1	1	0	PKO	2	2	0
POL	2	0	2	POP	6	6	0
POU	11	11	0	PRO	4	0	4
PRZ	1	1	0	R	20	0	20
ROE	16	16	0	RST	4	0	4
S	12	8	4	SCA	2	2	0
SEE	4	0	4	SEI	461	461	0
SHJ	3	1	4	SLE	16	16	0
SMA	12	12	0	STF	184	184	0
STI	11	11	0	STN	1	0	1
STT	20	20	0	TDS	1	0	1
TOB	231	129	102	TP	1	0	1
TRP	5	0	5	WAL	1	0	1
WEI	5	5	0	WFC	16	9	7
WG	1	0	1	WHC	3	1	2
WNO	1	0	1				

Total	Northern hemisphere	1591
Total	Southern H.	491
TOTAL		2083

Measures

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
12 00.2	-57 07	TOB 142		1987.263	107.5	4.52	1	48	F	Tob
12 00.5	-56 20	TOB 143		1976.414	183.5	22.27	1	48	F	Tob
12 00.8	-56 59	TOB 144		1976.414	88.6	16.33	1	48	F	Tob
12 08.0	-56 19	TOB 145		1976.414	258.7	23.24	1	48	F	Tob
12 19.7	-55 23	TOB 146		1976.414	135.5	17.16	1	48	F	Tob
12 20.1	-60 43	TOB 147		1987.066	261.0	19.52	1	48	F	Tob
12 20.1	-61 32	TOB 148		1987.263	317.6	20.87	1	48	F	Tob
12 20.3	-59 05	TOB 149		1987.263	149.6	23.79	1	48	F	Tob
12 20.4	-61 30	TOB 54		1987.066	285.7	15.49	1	48	F	Tob
12 20.8	-64 58	TOB 55		1987.263	67.4	38.33	1	48	F	Tob
12 20.8	-64 58	TOB 55	BC	1987.263	59.7	22.06	1	48	F	Tob
12 20.9	-56 08	PEL 1		1976.479	80.1	25.09	1	48	F	Tob
12 20.9	-56 08	PEL 1		1976.479	80.1	25.09	1	48	F	Tob
12 21.0	-63 54	TOB 56		1987.263	165.3	11.14	1	48	F	Tob
12 21.1	-62 03	TOB 57		1987.263	329.7	19.90	1	48	F	Tob
12 21.1	-64 36	TOB 58		1987.263	285.7	11.31	1	48	F	Tob
12 21.9	-64 34	TOB 59		1987.263	6.7	23.18	1	48	F	Tob
12 22.0	-62 33	TOB 60		1987.263	239.5	20.13	1	48	F	Tob
12 22.0	-64 42	TOB 61		1987.263	91.6	33.58	1	48	F	Tob
12 22.2	-58 28	TOB 62		1987.263	161.6	11.11	1	48	F	Tob
12 22.3	-61 17	TOB 63		1987.066	240.9	15.84	1	48	F	Tob
12 22.3	-61 17	TOB 63	AC	1987.066	168.5	24.42	1	48	F	Tob
12 22.3	-61 17	TOB 63	AD	1987.066	132.3	51.38	1	48	F	Tob
12 22.6	-59 25	TOB 64		1987.263	25.2	23.44	1	48	F	Tob
12 23.2	-61 58	TOB 65		1987.263	148.1	24.45	1	48	F	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
12 23.2	-61 58	TOB 65	AC	1987.263	188.2	26.93	1	48	F	Tob
12 23.2	-63 14	TOB 66		1987.263	325.3	22.49	1	48	F	Tob
12 23.3	-63 04	TOB 67		1987.263	332.9	13.82	1	48	F	Tob
12 23.7	-57 25	TOB 68		1987.066	148.3	15.20	1	48	F	Tob
12 23.7	-62 58	TOB 69		1987.263	215.1	15.38	1	48	F	Tob
12 24.4	-64 11	TOB 70		1987.263	108.4	25.57	1	48	F	Tob
12 24.6	-64 56	TOB 71		1987.263	163.1	19.91	1	48	F	Tob
12 25.2	-62 01	TOB 72		1987.263	98.5	18.51	1	48	F	Tob
12 25.2	-65 07	TOB 73		1987.263	266.1	26.60	1	48	F	Tob
12 27.4	-58 01	TOB 74		1987.263	121.7	23.98	1	48	F	Tob
12 28.6	-58 29	TOB 75		1987.066	285.9	15.09	1	48	F	Tob
12 28.6	-59 48	TOB 76		1987.263	169.5	18.68	1	48	F	Tob
12 28.7	-55 57	TOB 77		1976.479	162.6	24.25	1	48	F	Tob
12 28.7	-59 18	TOB 78		1987.066	302.0	20.33	1	48	F	Tob
12 28.7	-59 19	TOB 79		1987.066	218.1	20.76	1	48	F	Tob
12 29.1	-59 33	TOB 80		1987.263	40.3	20.36	1	48	F	Tob
12 30.0	-64 37	TOB 81		1987.263	307.2	10.40	1	48	F	Tob
12 30.0	-64 40	TOB 82		1987.263	162.3	15.47	1	48	F	Tob
12 30.6	-59 42	TOB 83		1987.066	238.9	14.70	1	48	F	Tob
12 31.0	-59 46	TOB 84		1987.066	317.1	14.32	1	48	F	Tob
12 31.1	-56 23	TOB 85		1976.479	25.3	23.59	1	48	F	Tob
12 31.6	-64 12	TOB 86		1987.263	348.5	13.89	1	48	F	Tob
12 32.0	-61 07	TOB 87		1987.066	213.0	12.66	1	48	F	Tob
12 32.2	-58 52	TOB 88		1987.066	92.6	14.76	1	48	F	Tob
12 32.3	-61 44	TOB 89		1987.066	226.6	44.61	1	48	F	Tob
12 32.4	-61 43	TOB 90		1987.066	214.0	21.64	1	48	F	Tob
12 34.5	-58 20	TOB 91		1987.066	69.4	23.33	1	48	F	Tob
12 34.6	-57 53	TOB 92		1987.066	52.7	24.11	1	48	F	Tob
12 34.9	-60 24	TOB 93		1987.066	30.1	24.39	1	48	F	Tob
12 35.1	-58 57	TOB 94		1987.066	209.1	12.26	1	48	F	Tob
12 35.1	-61 50	TOB 95		1987.066	71.1	38.59	1	48	F	Tob
12 35.7	-61 30	TOB 96		1987.066	95.5	42.39	1	48	F	Tob
12 35.8	-59 35	TOB 97		1987.066	25.7	8.49	1	48	F	Tob
12 35.8	-59 56	TOB 98		1987.066	100.0	13.41	1	48	F	Tob
12 36.3	-57 47	TOB 99		1987.066	101.8	14.71	1	48	F	Tob
12 36.3	-59 15	TOB 100		1987.066	341.1	14.86	1	48	F	Tob
12 36.8	-59 22	TOB 101		1987.066	46.4	15.28	1	48	F	Tob
12 37.1	-59 25	TOB 102		1987.066	151.3	25.98	1	48	F	Tob
12 38.0	-58 22	TOB 103		1987.066	139.8	30.90	1	48	F	Tob
12 38.0	-59 31	TOB 104		1987.066	154.7	21.46	1	48	F	Tob
12 38.3	-58 07	TOB 105		1987.066	279.8	15.62	1	48	F	Tob
12 38.4	-62 55	TOB 106		1987.066	283.7	2.20	1	48	F	Tob
12 38.5	-55 37	TOB 107		1976.479	5.0	27.32	1	48	F	Tob
12 39.0	-58 16	TOB 108		1987.066	91.0	25.75	1	48	F	Tob
12 39.0	-64 08	TOB 109		1987.263	32.2	31.90	1	48	F	Tob
12 41.3	-61 05	TOB 110		1987.066	88.7	15.25	1	48	F	Tob
12 41.6	-55 53	TOB 111		1976.479	83.7	19.22	1	48	F	Tob
12 42.2	-62 58	TOB 112		1987.066	225.6	16.44	1	48	F	Tob
12 42.3	-61 17	TOB 113		1987.066	133.1	6.80	1	48	F	Tob
12 42.8	-64 05	TOB 114		1987.263	148.2	13.88	1	48	F	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
12 43.6	-61 16	TOB 115		1987.066	311.7	18.75	1	48	F	Tob
12 44.4	-64 14	TOB 116		1987.263	227.1	13.00	1	48	F	Tob
12 44.7	-60 28	TOB 117		1987.066	327.7	32.72	1	48	F	Tob
12 45.2	-59 08	TOB 118		1987.066	261.6	14.44	1	48	F	Tob
12 45.4	-58 03	TOB 119		1987.066	199.6	21.30	1	48	F	Tob
12 45.6	-56 53	TOB 120		1976.479	294.0	26.02	1	48	F	Tob
12 46.5	-60 25	TOB 121		1987.066	17.2	19.89	1	48	F	Tob
12 47.1	-55 47	TOB 122		1976.479	342.6	6.06	1	48	F	Tob
12 47.6	-64 40	TOB 123		1987.263	28.0	15.67	1	48	F	Tob
12 48.0	-64 42	TOB 124		1987.263	68.7	12.48	1	48	F	Tob
12 49.2	-57 05	TOB 125		1987.066	274.9	21.40	1	48	F	Tob
12 49.7	-58 02	TOB 126		1987.066	176.2	22.05	1	48	F	Tob
12 50.6	-58 32	TOB 127		1987.066	93.2	15.10	1	48	F	Tob
12 54.0	-60 50	TOB 128		1987.066	4.2	15.41	1	48	F	Tob
12 54.8	-55 09	TOB 129		1987.463	22.1	28.29	1	48	F	Tob
12 57.5	-56 20	TOB 130		1987.463	71.6	22.23	1	48	F	Tob
12 57.5	-56 20	TOB 130	AC	1987.463	25.9	45.65	1	48	F	Tob
13 03.4	+70 04	HJ 2636		1984.167	165.6	9.84	1	48	F	Tob
13 04.2	+38 05	KZA 37		1983.132	65.7	23.96	1	48	F	Tob
13 04.4	+39 09	KZA 38		1982.392	306.2	22.92	1	48	F	Tob
13 05.8	+37 26	KZA 40		1983.132	282.4	57.18	1	48	F	Tob
13 06.2	+40 55	HJ 2639	BC	1982.392	103.5	23.47	1	48	F	Tob
13 07.6	+26 29	BUP 148		1982.386	144.1	198.18	1	48	F	Tob
13 09.1	+38 58	KZA 42	AC	1982.392	249.8	56.68	1	48	F	Tob
13 10.4	+39 21	KZA 43		1982.392	84.3	45.82	1	48	F	Tob
13 10.4	+37 44	KZA 44		1983.132	209.0	77.04	1	48	F	Tob
13 10.4	+37 44	KZA 44	AC	1983.132	5.0	93.30	1	48	F	Tob
13 11.6	+39 11	KZA 45		1982.392	296.5	52.19	1	48	F	Tob
13 12.4	+39 08	KZA 46		1982.392	323.6	49.79	1	48	F	Tob
13 16.4	+42 02	HJ 1230		1982.392	169.7	16.54	1	48	F	Tob
13 20.1	+45 25	KZA 48		1983.353	205.1	42.64	1	48	F	Tob
13 20.7	+34 15	KZA 49		1983.132	149.8	23.16	1	48	F	Tob
13 21.1	+35 48	KZA 50		1983.132	254.7	26.17	1	48	F	Tob
13 21.9	+44 16	KZA 54		1983.353	15.3	19.71	1	48	F	Tob
13 21.9	+34 33	KZA 53		1983.132	19.0	17.59	1	48	F	Tob
13 22.1	+43 54	KZA 55	AC	1983.392	59.8	66.54	1	48	F	Tob
13 23.0	+35 44	KZA 57		1984.164	55.3	23.67	1	48	F	Tob
13 23.2	+34 39	KZA 59		1984.164	173.0	35.13	1	48	F	Tob
13 23.5	+35 34	KZA 60		1984.164	210.0	11.31	1	48	F	Tob
13 23.6	+36 08	KZA 61	AC	1984.164	284.1	156.84	1	48	F	Tob
13 23.8	+36 06	KZA 62		1984.164	273.0	34.91	1	48	F	Tob
13 29.1	+22 11	STF1748	AC	1982.381	2.6	141.90	1	48	F	Tob
13 29.2	+31 04	STF1749		1982.386	354.9	21.82	1	48	F	Tob
13 30.7	+43 48	KZA 66		1982.392	266.3	77.58	1	48	F	Tob
13 33.7	+48 01	ODE 11		1983.126	135.	122.94	1	48	F	Tob
13 36.3	+35 14	KZA 71		1984.164	342.0	58.56	1	48	F	Tob
13 36.3	+35 14	KZA 71	AC	1984.184	0.0	87.84	1	48	F	Tob
13 37.0	+23 18	POU3145		1982.381	19.4	5.88	1	48	F	Tob
13 38.7	+38 23	KZA 75	AC	1984.164	350.8	64.86	1	48	F	Tob
13 41.1	+39 01	KZA 77		1982.392	144.4	58.04	1	48	F	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
13 41.9	+32 09	TOB 131		1984.386	198.7	10.42	1	48	F	Tob
13 46.6	+28 26	KOP 1		1982.386	184.6	19.91	1	48	F	Tob
13 59.4	+25 15	BUP 155	AC	1982.384	91.3	307.68	1	48	F	Tob
14 08.8	+77 15	HJ 2706		1983.340	80.9	12.17	1	48	F	Tob
14 16.2	+32 35	HZG 10		1982.389	0.9	117.54	1	48	F	Tob
14 16.2	+32 35	TOB 132	BC	1982.389	342.5	19.62	1	48	F	Tob
14 24.0	+29 58	HJ 549		1982.386	133.2	31.29	1	48	F	Tob
14 25.7	+23 38	BU 1442	AC	1982.384	73.4	79.50	1	48	F	Tob
14 55.6	+34 57	HJ 560		1982.389	296.4	39.26	1	48	F	Tob
14 55.7	+41 16	HJ 1260		1982.392	177.6	18.84	1	48	F	Tob
14 56.8	+74 54	S 666		1983.348	31.4	170.22	1	48	F	Tob
14 58.0	+40 13	HJ 1264		1982.392	317.2	19.02	1	48	F	Tob
14 58.4	+44 03	STF1896	AC	1982.392	341.8	65.04	1	48	F	Tob
15 02.5	+47 45	H 6 53		1983.126	0.5	86.70	1	48	F	Tob
15 09.5	+32 08	HJ 2767		1982.386	263.8	10.95	1	48	F	Tob
15 12.9	+46 50	HJ 2770	AC	1982.447	125.4	19.07	1	48	F	Tob
15 17.4	+43 48	STF1934	AC	1982.392	217.5	140.76	1	48	F	Tob
15 19.5	+29 52	KZA 78		1982.386	15.7	41.94	1	48	F	Tob
15 19.5	+31 20	KZA 79		1982.386	32.7	42.03	1	48	F	Tob
15 20.1	+60 23	STTA138	BC	1984.164	47.4	91.20	1	48	F	Tob
15 20.3	+35 59	HJ 251		1982.389	239.9	22.03	1	48	F	Tob
15 20.7	+31 33	KZA 80		1982.386	53.6	26.36	1	48	F	Tob
15 21.6	+30 59	KZA 83		1982.386	46.1	12.19	1	48	F	Tob
15 21.9	+30 52	KZA 84		1982.389	353.2	65.34	1	48	F	Tob
15 21.9	+30 52	KZA 84	AC	1982.389	9.0	98.76	1	48	F	Tob
15 22.4	+25 37	HJ 2777		1982.384	342.7	42.04	1	48	F	Tob
15 22.8	+30 49	KZA 85		1982.386	12.0	26.09	1	48	F	Tob
15 25.5	+30 20	KZA 88		1982.386	115.2	50.13	1	48	F	Tob
15 25.9	+30 31	KZA 89		1982.386	244.6	40.68	1	48	F	Tob
15 26.5	+43 51	BU 1449		1982.392	50.6	162.12	1	48	F	Tob
15 31.1	+40 22	KZA 93	AC	1982.392	91.8	49.70	1	48	F	Tob
15 31.1	+40 22	KZA 93	AD	1982.392	17.1	70.26	1	48	F	Tob
15 31.7	+39 41	KZA 95		1982.392	140.6	39.32	1	48	F	Tob
15 31.8	+40 15	KZA 98		1982.392	143.9	25.00	1	48	F	Tob
15 31.8	+40 15	KZA 98	AC	1982.392	123.6	53.66	1	48	F	Tob
15 32.2	+40 05	KZA 99		1982.392	336.0	26.81	1	48	F	Tob
15 32.3	+40 03	KZA 100		1982.392	45.7	19.65	1	48	F	Tob
15 32.3	+40 03	TOB 133	AC	1982.392	287.4	16.28	1	48	F	Tob
15 34.2	+40 55	KZA 102		1982.392	189.5	9.31	1	48	F	Tob
15 36.7	+39 54	KZA 105		1982.392	73.2	88.14	1	48	F	Tob
15 36.7	+39 54	KZA 105	AC	1982.392	117.9	133.55	1	48	F	Tob
15 36.7	+39 54	KZA 105	AD	1982.392	156.7	162.96	1	48	F	Tob
15 36.7	+39 54	KZA 105	AE	1982.392	132.	267.30	1	48	F	Tob
15 36.7	+39 54	KZA 105	AF	1982.392	177.9	355.02	1	48	F	Tob
15 36.7	+39 54	KZA 105	AG	1982.392	159.1	514.60	1	48	F	Tob
15 36.7	+39 54	KZA 105	AH	1982.392	135.0	534.10	1	48	F	Tob
15 37.0	+40 44	KZA 106		1982.392	202.0	49.66	1	48	F	Tob
15 38.5	+41 12	KZA 107		1982.392	328.3	27.55	1	48	F	Tob
15 52.3	+31 19	HJ 2795		1982.386	28.9	11.95	1	48	F	Tob
15 53.0	+60 07	HU 913	AC	1984.562	49.6	142.62	1	48	F	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
15 56.5	+57 17	STF1996	AC	1984.562	141.0	159.66	1	48	F	Tob
15 56.9	+36 13	HJ 258		1982.389	256.4	16.59	1	48	F	Tob
16 01.1	+28 08	AG 349		1984.477	232.	10.97	1	48	F	Tob
16 06.5	+60 28	PKO 13		1984.562	302.8	11.17	1	48	F	Tob
16 10.5	+47 48	STT 307		1982.477	201.9	18.54	1	48	F	Tob
16 11.8	+37 25	HJ 260		1982.389	29.8	19.32	1	48	F	Tob
16 14.7	+33 52	STF2032		1982.389	235.5	7.00	1	48	F	Tob
16 16.3	+41 42	HJ 1291		1982.392	112.1	19.85	1	48	F	Tob
16 16.7	+29 09	SHJ 223	CD	1983.477	92.3	63.00	1	48	F	Tob
16 17.2	+33 41	COU 980	AC	1983.205	80.7	39.92	1	48	F	Tob
16 18.6	+51 20	ES 627		1983.205	290.6	11.24	1	48	F	Tob
16 18.6	+51 18	TOB 134		1983.205	250.3	21.52	1	48	F	Tob
16 28.4	+37 24	HJ 261		1982.389	101.2	21.34	1	48	F	Tob
16 36.2	+52 55	STFA 30	BC	1983.205	15.2	89.64	1	48	F	Tob
16 43.5	+45 44	KZA 109		1983.452	175.4	62.22	1	48	F	Tob
16 43.5	+45 44	KZA 109	AC	1983.452	189.5	79.86	1	48	F	Tob
16 44.0	+44 59	KZA 110		1983.452	146.6	17.08	1	48	F	Tob
16 44.3	+45 51	KZA 111		1983.452	90.7	12.02	1	48	F	Tob
16 44.4	+43 46	TOB 135		1982.392	253.9	20.97	1	48	F	Tob
16 44.8	+35 44	POP1222	AD	1982.556	6.8	159.60	1	48	F	Tob
16 45.0	+51 25	SLE 15		1983.205	319.9	22.49	1	48	F	Tob
16 46.8	+45 28	KZA 112		1983.452	351.3	37.33	1	48	F	Tob
16 47.3	+46 37	KZA 113		1983.452	157.9	22.24	1	48	F	Tob
16 47.7	+46 15	KZA 114		1983.452	247.8	38.33	1	48	F	Tob
16 47.7	+46 15	KZA 114	AC	1983.452	239.8	60.78	1	48	F	Tob
16 47.7	+46 15	KZA 114	AD	1983.452	213.7	69.36	1	48	F	Tob
16 47.7	+46 15	KZA 114	AE	1983.452	229.2	79.62	1	48	F	Tob
16 49.2	+45 44	KZA 115		1983.452	287.9	30.57	1	48	F	Tob
16 51.8	+45 11	KZA 119		1983.452	120.8	21.47	1	48	F	Tob
16 53.4	+46 01	KZA 120		1983.452	80.2	11.26	1	48	F	Tob
16 54.7	+45 18	KZA 121	AC	1983.452	251.2	49.26	1	48	F	Tob
16 54.7	+45 18	KZA 121	AD	1983.452	220.1	180.30	1	48	F	Tob
16 56.0	+46 43	KZA 122	AC	1983.452	239.3	141.72	1	48	F	Tob
17 07.5	+35 57	HJ 264	AE	1982.556	100.0	244.20	1	48	F	Tob
17 08.6	+71 00	TOB 136		1983.348	259.2	21.82	1	48	F	Tob
17 10.8	+32 11	TOB 137		1983.290	259.4	42.00	1	48	F	Tob
17 11.8	+29 06	SLE 11		1982.553	285.5	8.82	1	48	F	Tob
17 12.0	+31 58	GYL 5		1983.290	319.9	16.90	1	48	F	Tob
17 12.6	+71 08	PRZ 13		1983.348	134.6	25.98	1	48	F	Tob
17 16.6	+26 35	WHC 15	AB-D	1982.386	324.9	123.12	1	48	F	Tob
17 19.1	+53 41	FUR 1		1982.351	155.4	28.57	1	48	F	Tob
17 20.0	+30 35	TOB 138		1982.553	39.0	11.45	1	48	F	Tob
17 27.7	+30 24	HO 416		1982.553	96.8	4.54	1	48	F	Tob
17 28.5	+23 29	TOB 139		1982.387	88.0	9.93	1	48	F	Tob
17 28.6	+23 30	POU3292		1982.387	114.0	22.59	1	48	F	Tob
17 31.6	+49 43	FOX 202		1983.290	234.4	45.19	1	48	F	Tob
17 31.7	+30 19	SLE 27	AD	1982.553	25.6	161.94	1	48	F	Tob
17 35.2	+25 45	WFC 196		1982.386	95.2	8.68	1	48	F	Tob
17 36.4	+25 37	TOB 140		1988.636	93.0	23.62	1	48	F	Tob
17 38.4	+29 16	HJ 1301		1988.636	101.0	6.84	1	48	F	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
17 40.0	+31 44	SEI 545		1982.553	152.8	4.90	1	48	F	Tob
17 45.2	+51 57	STF2225	AC	1983.553	244.8	229.74	1	48	F	Tob
17 45.2	+51 57	STF2225	CD	1983.553	292.1	8.14	1	48	F	Tob
17 45.7	+59 14	ES 1743		1983.293	231.7	29.06	1	48	F	Tob
17 45.9	+50 11	STF2229		1983.290	337.7	6.65	1	48	F	Tob
17 50.1	+31 30	SEI 548		1987.1	87.1	17.71	1	48	F	Tob
17 50.4	+25 05	HJ 1305		1988.636	291.6	23.42	1	48	F	Tob
17 55.1	+31 34	AG 215		1982.553	48.5	40.89	1	48	F	Tob
17 56.3	+62 37	STTA163	BC	1983.370	338.5	193.08	1	48	F	Tob
17 57.8	+37 44	TOB 141		1982.474	353.8	16.77	1	48	F	Tob
18 01.9	+31 23	SEI 554		1982.553	48.1	23.77	1	48	F	Tob
18 02.0	+31 53	SEI 555		1982.553	110.8	19.78	1	48	F	Tob
18 02.2	+20 58	BUP 178		1982.553	281.5	146.28	1	48	F	Tob
18 02.8	+75 47	STF2302	BC	1983.373	287.8	18.22	1	48	F	Tob
18 05.4	+30 29	SLE 131		1982.553	203.6	52.21	1	48	F	Tob
18 05.4	+30 29	SLE 131	AC	1982.553	206.1	66.96	1	48	F	Tob
18 09.3	+59 45	STF2300		1983.370	46.7	13.88	1	48	F	Tob
18 09.3	+59 45	STF2300	AD	1983.370	89.7	24.04	1	48	F	Tob
18 10.4	+33 56	SEI 559		1982.389	167.6	11.90	1	48	F	Tob
18 11.9	+34 17	SEI 561		1982.389	154.0	20.69	1	48	F	Tob
18 12.6	+41 23	STF2298	AC	1982.389	39.8	74.40	1	48	F	Tob
18 15.7	+37 23	ES 2664		1982.389	71.4	8.91	1	48	F	Tob
18 16.2	+51 20	STF2305		1983.438	323.7	5.17	1	48	F	Tob
18 23.8	+51 39	ES 187	AC	1983.553	125.8	90.66	1	48	F	Tob
18 23.9	+58 48	STF2323	BC	1983.370	20.9	85.74	1	48	F	Tob
18 26.7	+26 27	BU 1326	AC	1982.386	60.4	62.04	1	48	F	Tob
18 27.6	+25 09	KU 117		1982.386	16.2	19.49	1	48	F	Tob
18 29.2	+32 20	HJ 1326		1983.614	10.3	11.12	1	48	F	Tob
18 29.3	+21 44	J 2913	AC	1982.386	162.1	14.06	1	48	F	Tob
18 29.5	+60 47	TOB 150		1983.370	301.3	90.90	1	48	F	Tob
18 29.8	+39 30	SLE 182		1982.386	254.9	9.80	1	48	F	Tob
18 30.0	+37 10	BU 420	AC	1982.386	197.2	20.66	1	48	F	Tob
18 31.0	+38 57	SLE 187		1982.386	210.3	23.38	1	48	F	Tob
18 33.5	+39 34	SLE 208	AC	1982.392	3.3	62.40	1	48	F	Tob
18 34.4	+32 00	TOB 151		1982.614	286.5	25.42	1	48	F	Tob
18 35.2	+26 16	BUP 184	AC	1982.636	244.3	301.18	1	48	F	Tob
18 37.1	+32 01	SLE 220		1983.614	235.5	17.20	1	48	F	Tob
18 38.7	+53 00	SLE 232		1983.353	223.0	13.64	1	48	F	Tob
18 38.7	+24 39	HJ 1332		1982.636	231.7	26.89	1	48	F	Tob
18 39.4	+30 00	SLE 101		1983.614	234.8	20.18	1	48	F	Tob
18 40.5	+31 39	HO 437	AC	1983.614	272.8	39.97	1	48	F	Tob
18 41.3	+41 02	SLE 94		1982.392	102.7	15.99	1	48	F	Tob
18 42.2	+88 18	HJ 2971	BC	1988.707	354.3	12.65	1	48	F	Tob
18 43.0	+34 45	SEI 572		1982.389	56.8	24.09	1	48	F	Tob
18 43.0	+34 45	BKO 52	AC	1982.389	147.5	18.56	1	48	F	Tob
18 44.3	+39 40	STFA 37	AD	1982.392	172.3	211.78	1	48	F	Tob
18 44.3	+39 40	STFA 37	BC	1982.392	172.5	207.78	1	48	F	Tob
18 44.3	+39 40	STFA 37	BD	1982.392	171.7	211.32	1	48	F	Tob
18 52.1	+51 20	STF2416	AC	1983.515	39.6	122.46	1	48	F	Tob
18 53.0	+36 21	HJ 1354		1982.389	4.0	9.66	1	48	F	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
18 54.1	+27 18	HJ 1355		1983.614	41.8	11.40	1	48	F	Tob
18 58.1	+38 13	STF2427		1982.389	58.9	54.54	1	48	F	Tob
18 58.1	+38 13	STF2427	AC	1982.389	61.7	61.32	1	48	F	Tob
18 58.1	+38 13	STF2427	BC	1982.389	87.5	7.83	1	48	F	Tob
18 58.2	+30 11	ES 2670		1983.614	176.9	16.81	1	48	F	Tob
19 00.2	+31 22	HLM 14		1983.515	311.9	13.11	1	48	F	Tob
19 04.6	+23 20	STF2445	AC	1982.636	108.0	143.64	1	48	F	Tob
19 04.6	+23 20	STF2445	BC	1982.636	105.8	154.68	1	48	F	Tob
19 05.2	+23 26	BU 359	AC	1982.636	111.3	38.71	1	48	F	Tob
19 05.9	+35 02	HZG 13		1982.389	134.3	26.62	1	48	F	Tob
19 08.6	+37 55	STF2472	AD	1982.389	343.7	78.48	1	48	F	Tob
19 08.6	+37 55	STF2472	AE	1982.389	331.4	53.49	1	48	F	Tob
19 08.6	+37 55	STF2472	BD	1982.389	345.7	55.23	1	48	F	Tob
19 08.6	+37 55	STF2473	CD	1982.389	284.9	6.07	1	48	F	Tob
19 09.3	+41 06	TOB 152		1982.392	181.2	32.10	1	48	F	Tob
19 10.6	+37 01	A 152	AC	1982.389	167.7	18.68	1	48	F	Tob
19 10.8	+32 07	ES 350		1983.515	235.8	5.55	1	48	F	Tob
19 12.4	+30 21	GLP 16	AD	1983.515	199.7	69.90	1	48	F	Tob
19 12.4	+30 21	GLP 16	BD	1983.515	192.5	75.30	1	48	F	Tob
19 12.4	+30 21	GLP 16	CD	1983.515	126.5	43.46	1	48	F	Tob
19 12.5	+44 47	WFC 218		1982.392	1.9	8.45	1	48	F	Tob
19 13.0	+39 33	SEI 578		1982.392	175.0	19.69	1	48	F	Tob
19 13.2	+55 07	FOX 26	AC	1983.515	342.9	15.92	1	48	F	Tob
19 13.7	+39 31	TOB 153		1982.392	266.1	21.82	1	48	F	Tob
19 13.9	+22 52	HJ 2859	AC	1982.636	9.8	135.30	1	48	F	Tob
19 14.2	+26 26	AG 375		1982.636	295.	18.61	1	48	F	Tob
19 14.6	+31 30	SEI 583		1983.515	256.3	30.70	1	48	F	Tob
19 15.6	+32 09	SEI 586		1983.515	157.6	19.58	1	48	F	Tob
19 16.8	+67 42	STF2514	AC	1983.375	255.0	138.36	1	48	F	Tob
19 18.6	+20 38	WFC 219		1982.477	84.7	8.23	1	48	F	Tob
19 18.7	+35 14	BU 360		1982.389	69.5	6.47	1	48	F	Tob
19 19.7	+44 22	STF2507	AC	1982.392	150.6	29.81	1	48	F	Tob
19 19.7	+44 22	STF2507	BC	1982.392	111.4	5.18	1	48	F	Tob
19 20.6	+35 06	HLM 22		1982.389	254.1	10.55	1	48	F	Tob
19 21.2	+39 48	SEI 592		1982.392	93.9	15.34	1	48	F	Tob
19 23.4	+47 38	ES 1163	AD	1983.367	232.8	27.76	1	48	F	Tob
19 23.7	+39 38	SEI 593		1982.392	46.6	14.35	1	48	F	Tob
19 25.9	+33 39	HJ 1399		1983.518	205.9	26.98	1	48	F	Tob
19 26.0	+28 30	MLB 472		1983.518	352.9	8.53	1	48	F	Tob
19 26.2	+47 23	HJ 1401		1983.367	187.9	17.40	1	48	F	Tob
19 26.2	+39 14	TOB 154		1983.518	116.9	31.55	1	48	F	Tob
19 26.4	+34 28	SEI 601		1983.518	62.2	23.59	1	48	F	Tob
19 26.4	+34 28	TOB 155	AC	1983.518	114.3	36.09	1	48	F	Tob
19 26.8	+21 10	STF2523	AC	1982.477	144.2	251.58	1	48	F	Tob
19 27.0	+73 22	STF2550	BC	1983.458	165.3	78.60	1	48	F	Tob
19 28.9	+36 09	SEI 605		1983.518	283.6	26.13	1	48	F	Tob
19 29.1	+35 40	SEI 607		1983.518	131.5	23.62	1	48	F	Tob
19 29.3	+22 46	HJ 2876		1982.636	97.5	12.12	1	48	F	Tob
19 30.0	+40 10	MLB 978	AC	1982.392	308.2	44.74	1	48	F	Tob
19 30.4	+35 06	SEI 609		1983.518	301.1	19.99	1	48	F	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
19 30.7	+32 27	SEI 610		1983.518	23.5	19.65	1	48	F	Tob
19 30.7	+29 13	TOB 156		1983.518	267.0	15.33	1	48	F	Tob
19 31.1	+31 46	SEI 613		1983.518	1.9	15.54	1	48	F	Tob
19 31.4	+36 43	STF2538	AD	1983.518	249.3	46.80	1	48	F	Tob
19 31.5	+35 14	SEI 616		1983.518	126.0	24.32	1	48	F	Tob
19 31.5	+32 47	SEI 615		1983.518	211.8	22.41	1	48	F	Tob
19 31.6	+32 14	SEI 617		1983.518	135.5	29.91	1	48	F	Tob
19 31.7	+53 00	STF2542		1983.518	254.3	11.54	1	48	F	Tob
19 31.7	+53 00	STF2542	AC	1983.518	268.4	40.84	1	48	F	Tob
19 31.7	+33 48	GYL 17		1983.518	230.2	21.98	1	48	F	Tob
19 32.0	+35 15	SEI 619		1983.518	17.2	23.03	1	48	F	Tob
19 32.1	+28 16	FOX 242	AD	1983.518	241.3	57.15	1	48	F	Tob
19 32.2	+35 22	SEI 620		1983.518	27.5	22.37	1	48	F	Tob
19 32.2	+34 57	SEI 621		1983.518	59.9	15.39	1	48	F	Tob
19 32.8	+32 51	SEI 624		1983.518	179.5	27.33	1	48	F	Tob
19 33.0	+34 53	SEI 626		1983.518	174.6	13.32	1	48	F	Tob
19 33.5	+36 11	SEI 630		1983.518	33.7	15.41	1	48	F	Tob
19 33.6	+32 29	SEI 629		1983.518	110.3	19.41	1	48	F	Tob
19 33.7	+50 03	HJ 1418		1983.367	11.5	29.62	1	48	F	Tob
19 34.0	+31 46	TOB 157		1983.518	127.3	20.23	1	48	F	Tob
19 34.1	+33 01	SEI 638		1983.518	262.4	25.63	1	48	F	Tob
19 34.1	+31 47	SEI 636		1983.518	341.7	24.85	1	48	F	Tob
19 34.9	+32 32	SEI 640		1983.515	150.9	21.01	1	48	F	Tob
19 35.5	+46 26	STTA187	BC	1983.367	228.6	81.00	1	48	F	Tob
19 35.5	+32 30	SEI 643		1983.515	54.5	25.21	1	48	F	Tob
19 36.0	+29 24	SLE 647	AC	1983.515	56.3	40.23	1	48	F	Tob
19 36.2	+31 57	SEI 645		1983.515	28.1	20.95	1	48	F	Tob
19 36.3	+35 40	STT 377	BC	1983.515	154.3	26.17	1	48	F	Tob
19 36.4	+50 13	STT 591	CD	1983.367	14.2	90.36	1	48	F	Tob
19 36.5	+25 00	STF2548		1982.636	94.4	9.66	1	48	F	Tob
19 37.3	+35 55	SEI 650		1982.636	151.8	16.08	1	48	F	Tob
19 37.3	+35 55	TOB 158	AC	1982.636	323.8	28.81	1	48	F	Tob
19 37.8	+38 11	SEI 652		1983.515	227.2	18.17	1	48	F	Tob
19 38.0	+33 54	STT 379		1983.515	83.5	25.00	1	48	F	Tob
19 39.0	+39 49	SEI 655		1982.392	107.4	24.96	1	48	F	Tob
19 39.4	+39 49	TOB 159		1982.392	150.6	37.47	1	48	F	Tob
19 39.6	+29 45	ABH 124	AF	1983.515	180.3	88.92	1	48	F	Tob
19 40.2	+26 11	A 272	AC	1982.636	308.5	14.93	1	48	F	Tob
19 40.7	+66 10	MLB 218	AC	1983.679	331.5	53.19	1	48	F	Tob
19 40.7	+23 43	STF2560		1982.636	298.2	14.41	1	48	F	Tob
19 41.4	+33 13	HJ 1430		1983.515	153.0	18.46	1	48	F	Tob
19 41.9	+67 33	MLB1085		1983.688	181.7	14.97	1	48	F	Tob
19 42.1	+31 32	SEI 661		1983.515	151.9	22.12	1	48	F	Tob
19 42.5	+56 55	HJ 2896		1983.515	20.2	19.09	1	48	F	Tob
19 43.3	+37 54	SEI 668		1983.515	339.4	24.22	1	48	F	Tob
19 43.7	+32 25	HJ 1433		1983.515	298.1	19.02	1	48	F	Tob
19 44.3	+34 01	GYL 20		1983.515	112.5	25.52	1	48	F	Tob
19 45.7	+36 05	STF2578	AF	1983.515	250.3	145.50	1	48	F	Tob
19 47.1	+27 01	OSB 8		1982.636	13.5	12.59	1	48	F	Tob
19 47.1	+27 01	TOB 160	AC	1982.636	210.0	30.89	1	48	F	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
19 49.0	+34 43	SEI 686		1983.515	221.6	20.48	1	48	F	Tob
19 50.1	+47 48	AG 240		1983.452	255.2	14.43	1	48	F	Tob
19 50.3	+33 51	SEI 693		1983.518	15.3	18.46	1	48	F	Tob
19 50.3	+22 40	BU 361	AC	1982.636	77.5	56.68	1	48	F	Tob
19 50.4	+34 12	SEI 694		1983.518	177.5	23.27	1	48	F	Tob
19 51.0	+36 50	SEI 698		1983.518	19.9	17.00	1	48	F	Tob
19 51.1	+36 59	SEI 701		1983.518	53.8	20.37	1	48	F	Tob
19 51.3	+35 35	SEI 702		1983.518	258.2	18.30	1	48	F	Tob
19 51.3	+34 34	SEI 700		1983.518	176.1	24.89	1	48	F	Tob
19 51.5	+25 22	HJ 1443		1982.636	196.7	17.76	1	48	F	Tob
19 51.9	+20 32	COU 824	AC	1988.392	289.6	20.95	1	48	F	Tob
19 52.4	+25 51	STT 388	BC	1982.636	128.7	27.91	1	48	F	Tob
19 52.7	+34 25	SEI 709		1983.518	331.6	12.38	1	48	F	Tob
19 52.8	+36 44	SEI 710		1983.518	28.7	21.72	1	48	F	Tob
19 53.6	+49 15	TOB 161		1983.452	220.3	21.64	1	48	F	Tob
19 53.7	+34 42	SEI 716		1983.614	110.0	24.50	1	48	F	Tob
19 53.9	+39 23	SEI 719		1983.614	58.1	15.89	1	48	F	Tob
19 54.4	+39 18	SEI 722	AC	1983.674	68.2	20.76	1	48	F	Tob
19 54.4	+39 18	HJ 2909	AD	1983.674	244.0	30.53	1	48	F	Tob
19 54.7	+34 53	TOB 162	AC	1983.614	253.1	24.18	1	48	F	Tob
19 55.5	+39 19	SEI 733		1983.614	140.2	21.42	1	48	F	Tob
19 55.9	+32 56	SEI 732		1984.510	265.9	24.78	1	48	F	Tob
19 56.3	+37 08	SEI 739		1983.614	170.9	23.77	1	48	F	Tob
19 56.4	+34 48	SEI 737		1983.614	68.6	26.07	1	48	F	Tob
19 57.0	+83 19	WFC 227		1983.677	52.2	6.38	1	48	F	Tob
19 57.3	+39 27	SEI 744		1983.614	86.1	16.82	1	48	F	Tob
19 57.7	+37 55	HJ 1457		1983.614	218.0	12.52	1	48	F	Tob
19 57.9	+38 43	SEI 751		1983.614	258.0	20.17	1	48	F	Tob
19 57.9	+38 43	TOB 163	AC	1983.614	73.7	23.86	1	48	F	Tob
19 58.1	+34 22	SEI 752		1983.614	65.6	12.08	1	48	F	Tob
19 58.6	+34 24	SEI 754		1983.614	358.1	28.02	1	48	F	Tob
19 58.8	+31 38	SEI 756		1984.510	335.1	17.76	1	48	F	Tob
19 59.1	+76 30	HU 956	AC	1984.660	132.4	138.72	1	48	F	Tob
19 59.2	+35 03	SEI 761		1984.616	185.5	20.28	1	48	F	Tob
19 59.3	+38 29	SEI 772		1984.614	354.7	22.09	1	48	F	Tob
19 59.3	+38 29	SEI 771	AC	1984.614	280.9	24.02	1	48	F	Tob
19 45.7	+36 12	SEI 677	AC	1983.518	177.6	16.12	1	48	F	Tob
20 00.2	+34 59	SEI 776		1982.614	158.5	13.29	1	48	F	Tob
20 00.2	+22 51	ROE 10		1982.636	66.0	8.93	1	48	F	Tob
20 00.4	+34 34	SEI 779		1982.614	116.0	16.41	1	48	F	Tob
20 00.5	+67 59	MLB 359	AC	1983.679	326.1	33.75	1	48	F	Tob
20 00.7	+36 35	WEB 9	CD	1983.679	324.6	13.66	1	48	F	Tob
20 01.0	+37 42	FOX 246	AB-D	1983.679	169.8	102.36	1	48	F	Tob
20 01.0	+33 46	SEI 785		1983.679	137.1	28.97	1	48	F	Tob
20 01.2	+34 51	SEI 788		1983.679	148.8	29.56	1	48	F	Tob
20 01.3	+34 26	SEI 790		1983.679	115.5	25.01	1	48	F	Tob
20 01.3	+33 46	SEI 789		1983.679	348.1	17.67	1	48	F	Tob
20 01.9	+31 39	AG 245		1984.510	353.3	14.50	1	48	F	Tob
20 02.0	+34 11	SEI 800		1983.614	349.5	24.22	1	48	F	Tob
20 02.3	+33 54	SEI 804		1983.614	90.0	26.88	1	48	F	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
20 02.4	+37 28	SEI 813		1983.614	330.9	24.52	1	48	F	Tob
20 02.4	+37 06	SEI 810		1983.614	157.4	19.47	1	48	F	Tob
20 02.7	+33 49	SEI 815		1983.614	0.4	18.37	1	48	F	Tob
20 02.7	+33 49	SEI 816	AC	1983.614	113.7	21.17	1	48	F	Tob
20 03.1	+33 43	SEI 818		1983.614	207.1	16.18	1	48	F	Tob
20 03.3	+34 03	SEI 822		1983.614	212.3	23.34	1	48	F	Tob
20 03.5	+36 01	STF2624	BC	1983.614	327.3	44.48	1	48	F	Tob
20 03.5	+34 48	SEI 824		1983.614	323.4	11.29	1	48	F	Tob
20 03.8	+43 59	HJ 1472		1983.674	221.4	15.18	1	48	F	Tob
20 04.3	+34 31	SEI 836		1983.614	4.6	15.70	1	48	F	Tob
20 05.2	+49 23	ES 2689	BC	1983.452	7.4	17.61	1	48	F	Tob
20 05.3	+30 10	HJ 1474		1984.510	351.9	12.94	1	48	F	Tob
20 05.4	+27 16	HJ 1473		1984.510	141.3	10.24	1	48	F	Tob
20 05.7	+37 11	SEI 850		1983.614	339.5	26.27	1	48	F	Tob
20 05.8	+35 56	ABH 129	AF	1983.614	91.8	88.08	1	48	F	Tob
20 05.8	+25 36	HJ 1479		1982.636	2.7	33.61	1	48	F	Tob
20 05.9	+35 52	SEI 856		1983.614	301.3	22.29	1	48	F	Tob
20 06.0	+37 14	SEI 866		1983.614	327.0	22.46	1	48	F	Tob
20 06.0	+37 14	TOB 165	AD	1983.614	39.7	43.33	1	48	F	Tob
20 06.0	+37 14	TOB 165	BC	1983.614	32.1	22.21	1	48	F	Tob
20 06.0	+37 14	TOB 165	CD	1983.614	98.7	28.45	1	48	F	Tob
20 06.0	+35 45	TOB 166		1983.614	253.3	20.70	1	48	F	Tob
20 06.3	+35 38	SEI 872		1983.614	56.4	32.40	1	48	F	Tob
20 06.4	+31 47	GYL 31		1984.510	180.0	68.04	1	48	F	Tob
20 06.5	+36 09	SEI 880		1983.614	297.2	19.37	1	48	F	Tob
20 06.5	+36 09	BKO 85	BD	1983.614	270.5	28.58	1	48	F	Tob
20 06.5	+33 02	GYL 23		1984.510	183.2	14.20	1	48	F	Tob
20 06.8	+36 11	SEI 884		1983.614	352.6	24.70	1	48	F	Tob
20 06.9	+35 45	SEI 886		1983.614	119.9	29.57	1	48	F	Tob
20 06.9	+32 46	GYL 32		1984.510	7.8	80.58	1	48	F	Tob
20 07.0	+66 18	STF2650		1983.679	227.8	21.67	1	48	F	Tob
20 07.0	+35 54	SEI 887		1983.614	200.0	23.17	1	48	F	Tob
20 07.0	+35 54	SEI 888	AC	1983.614	54.8	21.65	1	48	F	Tob
20 07.2	+36 16	SEI 891		1983.614	172.4	18.88	1	48	F	Tob
20 07.3	+35 53	SEI 892		1983.614	334.7	14.30	1	48	F	Tob
20 07.4	+35 53	SEI 894		1983.614	343.1	28.92	1	48	F	Tob
20 07.5	+36 18	TOB 167		1983.614	131.2	12.58	1	48	F	Tob
20 07.6	+36 27	SEI 898		1983.614	164.0	28.79	1	48	F	Tob
20 07.6	+36 27	SEI 899	BC	1983.614	112.5	22.83	1	48	F	Tob
20 07.7	+32 40	TOB 168		1984.510	293.1	17.86	1	48	F	Tob
20 07.8	+36 17	SEI 903		1983.614	193.4	11.48	1	48	F	Tob
20 07.8	+36 03	SEI 904		1983.614	268.2	12.53	1	48	F	Tob
20 07.8	+35 20	SEI 901		1983.614	88.3	15.37	1	48	F	Tob
20 08.0	+35 21	SEI 907		1983.614	203.8	21.21	1	48	F	Tob
20 08.0	+32 35	SEI 900	CD	1984.510	224.5	28.87	1	48	F	Tob
20 08.5	+37 07	SEI 912		1983.614	157.6	29.73	1	48	F	Tob
20 08.5	+37 07	TOB 169	AC	1983.614	105.6	25.21	1	48	F	Tob
20 08.5	+36 19	SEI 911		1983.614	356.1	27.68	1	48	F	Tob
20 08.6	+36 23	TOB 170		1983.614	0.6	11.42	1	48	F	Tob
20 08.6	+36 10	SEI 914		1983.614	218.0	10.64	1	48	F	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
20 08.7	+31 30	SEI 910		1984.510	108.4	10.91	1	48	F	Tob
20 09.0	+36 26	SEI 920		1983.614	52.7	14.52	1	48	F	Tob
20 09.2	+35 40	SEI 922		1983.614	216.3	18.90	1	48	F	Tob
20 09.2	+32 43	TOB 171		1984.510	116.4	19.27	1	48	F	Tob
20 09.5	+34 31	TOB 172		1983.614	109.8	7.90	1	48	F	Tob
20 09.6	+35 06	TOB 173		1982.614	185.3	15.42	1	48	F	Tob
20 09.6	+34 59	SEI 929		1983.614	30.2	21.07	1	48	F	Tob
20 09.7	+35 35	SEI 934	AC	1983.614	171.9	19.36	1	48	F	Tob
20 09.7	+35 10	SEI 937		1983.614	67.6	25.62	1	48	F	Tob
20 09.9	+56 57	ES 132	BC	1983.518	59.1	28.03	1	48	F	Tob
20 10.1	+36 17	SEI 939		1983.614	215.2	25.79	1	48	F	Tob
20 10.2	+41 30	WFC 229		1983.674	303.3	4.77	1	48	F	Tob
20 10.5	+36 35	SEI 948		1983.614	87.8	21.92	1	48	F	Tob
20 10.5	+36 14	SEI 947		1983.614	289.6	15.41	1	48	F	Tob
20 10.5	+29 20	MLB 477	AC	1984.510	23.6	112.80	1	48	F	Tob
20 10.7	+36 57	SEI 953		1983.614	301.4	17.23	1	48	F	Tob
20 10.8	+36 54	SEI 956		1983.614	75.4	12.24	1	48	F	Tob
20 10.9	+37 12	TOB 174		1983.614	260.7	24.40	1	48	F	Tob
20 11.0	+35 59	SEI 961		1983.614	21.3	13.41	1	48	F	Tob
20 11.2	+37 18	SEI 965		1983.614	220.1	20.53	1	48	F	Tob
20 11.3	+35 27	SEI 966		1983.614	245.3	26.20	1	48	F	Tob
20 11.5	+36 39	SEI 974		1983.614	12.7	19.48	1	48	F	Tob
20 11.5	+36 39	TOB 175	AC	1983.614	93.5	54.04	1	48	F	Tob
20 11.5	+36 39	TOB 175	AD	1983.614	120.8	36.22	1	48	F	Tob
20 11.7	+37 20	SEI 982		1983.614	63.0	19.52	1	48	F	Tob
20 11.7	+37 06	SEI 980		1983.614	185.2	23.62	1	48	F	Tob
20 11.9	+35 50	SEI 985		1983.614	16.8	16.8	1	48	F	Tob
20 12.0	+36 40	SEI 989		1983.614	152.8	29.65	1	48	F	Tob
20 12.0	+36 14	TOB 176		1983.614	196.	18.91	1	48	F	Tob
20 12.1	+37 10	SEI 995		1983.614	44.6	23.02	1	48	F	Tob
20 12.1	+36 03	SEI 990		1983.614	295.2	26.78	1	48	F	Tob
20 12.2	+36 03	SEI 994		1983.614	252.2	27.95	1	48	F	Tob
20 12.2	+35 48	SEI 992		1983.614	77.5	26.28	1	48	F	Tob
20 12.3	+32 05	STF2649	AC	1984.510	284.4	130.02	1	48	F	Tob
20 12.3	+32 05	STF2649	AD	1984.510	36.6	175.20	1	48	F	Tob
20 12.4	+37 11	SEI 999		1983.614	270.1	24.53	1	48	F	Tob
20 12.4	+35 49	TOB 177		1983.614	220.5	21.57	1	48	F	Tob
20 12.5	+37 17	SEI1005		1983.614	55.7	26.33	1	48	F	Tob
20 12.6	+36 18	SEI1004		1983.614	105.7	26.40	1	48	F	Tob
20 12.6	+36 18	TOB 178	AC	1983.614	289.6	26.98	1	48	F	Tob
20 12.6	+36 14	SEI1003		1983.614	284.1	22.90	1	48	F	Tob
20 12.6	+25 39	OPI 22	BE	1982.636	242.8	39.53	1	48	F	Tob
20 12.7	+36 45	SEI1006		1983.614	304.4	17.05	1	48	F	Tob
20 12.8	+36 38	SEI1010		1983.614	24.5	25.46	1	48	F	Tob
20 12.9	+34 29	AG 250		1983.614	48.0	8.16	1	48	F	Tob
20 13.0	+34 50	SEI1012		1983.614	48.9	13.72	1	48	F	Tob
20 13.3	+36 34	SEI1016		1983.614	344.4	11.96	1	48	F	Tob
20 13.5	+36 34	SEI1020		1983.614	275.9	13.85	1	48	F	Tob
20 13.5	+36 34	SEI1022	AC	1983.614	217.0	21.17	1	48	F	Tob
20 13.6	+53 07	STF2658	BC	1984.518	210.1	64.50	1	48	F	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
20 13.6	+35 53	SEI1021		1983.614	248.2	12.79	1	48	F	Tob
20 13.6	+20 21	BU 1484		1982.477	321.2	23.15	1	48	F	Tob
20 13.7	+37 13	SEI1026		1983.614	86.7	30.35	1	48	F	Tob
20 13.8	+29 45	TOB 179		1984.510	91.5	22.70	1	48	F	Tob
20 13.9	+29 42	TOB 180		1984.510	298.8	23.18	1	48	F	Tob
20 13.8	+37 10	TOB 181		1983.614	15.9	15.16	1	48	F	Tob
20 14.1	+36 17	SEI1031		1983.614	61.5	18.92	1	48	F	Tob
20 14.1	+22 13	STF2655	AC	1982.636	154.4	60.60	1	48	F	Tob
20 14.2	+35 22	ES 204		1982.614	287.4	13.88	1	48	F	Tob
20 14.4	+39 20	TOB 182	AC	1982.674	194.0	41.14	1	48	F	Tob
20 14.5	+36 40	BLL 48		1983.614	117.1	113.70	1	48	F	Tob
20 14.6	+36 35	SEI1041		1983.614	23.5	22.02	1	48	F	Tob
20 15.1	+39 29	MLB 982		1983.674	182.5	29.49	1	48	F	Tob
20 16.0	+37 58	SEI1048		1983.614	123.3	19.90	1	48	F	Tob
20 16.0	+29 29	MLB 478	AC	1984.510	76.1	154.68	1	48	F	Tob
20 16.2	+37 45	TOB 183		1983.614	255.9	15.56	1	48	F	Tob
20 17.3	+52 01	ES 660		1983.518	305.6	30.23	1	48	F	Tob
20 17.7	+33 31	HJ 1500		1983.614	56.8	14.76	1	48	F	Tob
20 17.8	+36 45	SEI1067		1983.614	62.3	16.38	1	48	F	Tob
20 17.9	+37 12	SEI1071		1983.614	11.8	26.70	1	48	F	Tob
20 18.1	+32 02	SEI1068		1983.515	13.8	16.88	1	48	F	Tob
20 18.3	+20 02	HJ 912	AC	1982.477	173.1	90.42	1	48	F	Tob
20 19.2	+36 47	SEI1081		1983.614	231.2	18.59	1	48	F	Tob
20 19.2	+36 47	TOB 184	BC	1983.614	170.7	23.59	1	48	F	Tob
20 19.3	+25 21	POU4363		1983.614	42.6	21.77	1	48	F	Tob
20 19.6	+38 08	SEI1084		1983.614	246.9	26.08	1	48	F	Tob
20 19.6	+38 08	TOB 185	AC	1983.614	259.9	13.51	1	48	F	Tob
20 20.1	+37 00	SEI1087		1983.614	253.2	11.53	1	48	F	Tob
20 21.0	+39 19	SEI1097		1983.674	47.1	27.23	1	48	F	Tob
20 21.0	+39 19	TOB 186	BC	1983.674	43.8	16.13	1	48	F	Tob
20 21.3	+37 58	SEI1098		1983.674	144.6	22.15	1	48	F	Tob
20 21.6	+38 36	SEI1102		1983.674	155.4	18.82	1	48	F	Tob
20 22.1	+38 55	SEI1104		1983.674	191.8	17.96	1	48	F	Tob
20 22.3	+47 48	HJ 1510		1983.452	157.8	4.23	1	48	F	Tob
20 22.3	+47 48	ES 29	AD	1983.452	317.7	31.79	1	48	F	Tob
20 22.3	+47 48	ES 29	AE	1983.452	121.5	55.46	1	48	F	Tob
20 22.3	+37 59	SEI1105		1983.674	188.0	17.15	1	48	F	Tob
20 23.2	+35 42	HJ 1506	AC	1983.674	193.5	35.67	1	48	F	Tob
20 23.8	+35 31	SEI1114		1983.674	57.6	17.73	1	48	F	Tob
20 23.9	+32 38	SEI1112		1983.515	207.9	19.95	1	48	F	Tob
gg										
20 25.7	+40 04	POP 199	AC	1983.674	245.5	59.54	1	48	F	Tob
20 25.9	+37 58	SEI1123		1983.674	138.1	27.76	1	48	F	Tob
20 26.5	+56 19	BU 433	AC	1983.518	237.4	28.21	1	48	F	Tob
20 27.0	+45 39	HJ 1518		1983.452	87.7	14.86	1	48	F	Tob
20 27.0	+33 29	HJ 1515		1983.515	23.5	14.89	1	48	F	Tob
20 27.7	+45 07	ROE 43		1983.674	319.6	16.85	1	48	F	Tob
20 27.7	+45 07	ROE 43	AD	1983.674	271.1	42.42	1	48	F	Tob
20 27.7	+45 07	ROE 43	AE	1983.674	281.8	83.52	1	48	F	Tob
20 27.7	+45 07	ROE 43	AF	1983.674	336.0	86.40	1	48	F	Tob
20 27.7	+45 07	ROE 43	AG	1983.674	282.1	101.58	1	48	F	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
20 28.0	+30 08	BU 62	AD	1983.515	267.3	45.91	1	48	F	Tob
20 28.8	+35 41	SEI1130		1983.674	32.6	12.55	1	48	F	Tob
20 28.9	+56 55	STI2535		1983.518	225.0	12.77	1	48	F	Tob
20 28.9	+56 55	TOB 187	AC	1983.518	128.3	26.05	1	48	F	Tob
20 28.9	+56 55	TOB 187	AD	1983.518	188.5	28.83	1	48	F	Tob
20 29.3	+37 31	WEI 35	AC	1983.674	99.8	87.54	1	48	F	Tob
20 29.3	+37 31	WEI 35	BC	1983.674	97.3	89.82	1	48	F	Tob
20 29.3	+37 31	WEI 35	CD	1983.674	203.5	11.91	1	48	F	Tob
20 29.6	+39 01	SEI1137		1983.674	310.3	22.75	1	48	F	Tob
20 29.6	+38 36	SEI1136		1983.674	251.9	11.49	1	48	F	Tob
20 30.2	+38 23	SEI1141		1983.674	174.5	22.20	1	48	F	Tob
20 30.2	+26 51	BUP 213	AD	1983.614	280.1	94.62	1	48	F	Tob
20 30.8	+37 49	SEI1147	AC	1983.674	270.0	18.17	1	48	F	Tob
20 31.1	+38 54	SEI1149		1983.674	202.4	19.65	1	48	G	Tob
20 31.1	+38 47	SEI1150		1983.674	72.6	22.28	1	48	G	Tob
20 31.3	+36 54	TOB 188		1983.674	262.5	16.41	1	48	F	Tob
20 31.7	+45 40	HJ 1533		1983.452	187.8	9.6	1	48	G	Tob
20 31.8	+22 19	ROE 12		1983.614	28.2	11.18	1	48	G	Tob
20 32.3	+37 26	SEI1156		1983.674	83.1	5.47	1	48	G	Tob
20 32.7	+39 16	SEI1160		1983.674	50.1	14.25	1	48	G	Tob
20 33.0	+39 03	SEI1163		1983.674	218.9	29.15	1	48	G	Tob
20 33.2	+39 10	SEI1165		1983.674	4.3	11.19	1	48	G	Tob
20 33.5	+47 03	HJ 1541	AC	1983.452	268.9	8.05	1	48	G	Tob
20 33.5	+38 58	SEI1166		1983.674	71.9	17.24	1	48	G	Tob
20 33.6	+21 11	HJ 2979	AC	1983.512	0.7	18.35	1	48	G	Tob
20 33.9	+32 58	GYL 36		1983.515	149.9	20.56	1	48	G	Tob
20 34.0	+37 37	SEI1170		1983.674	28.1	16.93	1	48	G	Tob
20 34.3	+45 20	ES 804		1983.674	117.5	30.93	1	48	G	Tob
20 34.4	+38 52	SEI1172		1983.674	148.4	21.82	1	48	G	Tob
20 34.7	+49 57	ES 2696		1983.452	137.7	10.14	1	48	G	Tob
20 34.9	+38 49	SEI1176		1983.674	11.3	19.86	1	48	G	Tob
20 34.9	+38 40	SEI1177		1983.674	142.2	12.82	1	48	G	Tob
20 35.0	+37 57	SEI1178		1983.674	174.8	20.04	1	48	G	Tob
20 35.0	+34 19	J 791	AC	1983.674	234.7	17.60	1	48	G	Tob
20 35.0	+33 23	HJ 1543		1983.674	25.9	16.50	1	48	G	Tob
20 35.0	+32 59	HJ 1542		1983.674	227.7	15.86	1	48	G	Tob
20 35.1	+37 25	SEI1179		1983.674	70.4	26.44	1	48	G	Tob
20 35.2	+56 22	HJ 1552		1983.518	226.1	40.38	1	48	G	Tob
20 35.5	+37 49	SEI1184		1983.674	36.5	26.62	1	48	G	Tob
20 35.7	+37 47	TOB 190		1983.674	69.4	17.69	1	48	G	Tob
20 35.9	+37 29	SEI1186		1983.674	188.9	11.93	1	48	G	Tob
20 36.2	+37 37	SEI1188		1983.674	76.9	15.66	1	48	G	Tob
20 36.2	+37 37	TOB 191	BD	1983.674	134.2	36.85	1	48	G	Tob
20 36.9	+36 52	SEI1192		1983.674	283.0	30.39	1	48	G	Tob
20 37.3	+38 22	SEI1194		1983.674	112.0	25.09	1	48	G	Tob
20 37.4	+37 21	TOB 192		1983.674	106.2	31.87	1	48	G	Tob
20 37.9	+37 25	SEI1196		1983.674	334.9	17.97	1	48	G	Tob
20 38.0	+37 41	TOB 193		1983.674	230.6	28.38	1	48	G	Tob
20 38.0	+37 41	TOB 193	AC	1983.674	266.8	31.18	1	48	G	Tob
20 38.0	+25 18	POU4760		1983.674	266.3	14.87	1	48	G	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
20 38.2	+37 42	SEI1201		1983.674	349.2	23.45	1	48	G	Tob
20 38.6	+44 38	ES 667		1983.674	195.0	6.25	1	48	G	Tob
20 39.1	+37 17	SEI1207		1983.674	121.3	26.55	1	48	G	Tob
20 39.1	+36 19	SEI1206		1983.674	148.4	26.65	1	48	G	Tob
20 39.1	+35 43	SEI1205		1983.674	72.7	21.80	1	48	G	Tob
20 39.3	+27 14	HJ 1557	A-Bab	1983.674	204.9	12.05	1	48	G	Tob
20 39.4	+35 41	TOB 194		1983.674	304.0	18.81	1	48	G	Tob
20 39.7	+21 41	STF2710		1983.674	162.2	18.62	1	48	G	Tob
20 40.5	+40 10	SEI1214		1983.674	76.9	20.29	1	48	G	Tob
20 40.5	+40 10	TOB 196	BC	1983.674	31.9	23.16	1	48	G	Tob
20 40.6	+36 03	SEI1213		1983.674	244.6	28.81	1	48	G	Tob
20 40.8	+53 07	ES 2698		1983.518	34.0	8.97	1	48	G	Tob
20 41.0	+33 15	GYL 38		1983.515	273.4	16.17	1	48	G	Tob
20 41.0	+20 01	HJ 2987		1983.512	119.3	5.12	1	48	G	Tob
20 41.4	+36 44	SEI1215		1983.674	134.4	28.83	1	48	G	Tob
20 41.5	+36 35	SEI1216		1983.674	113.3	11.65	1	48	G	Tob
20 42.1	+50 13	ES 91	BC	1983.452	239.7	15.79	1	48	G	Tob
20 42.3	+45 49	STT 411		1983.452	347.9	30.41	1	48	G	Tob
20 43.3	+25 49	BUP 217	AD	1983.721	102.3	386.34	1	48	G	Tob
20 43.3	+25 49	BUP 217	AE	1983.721	285.9	444.24	1	48	G	Tob
20 43.5	+39 19	SEI1229		1983.674	157.9	18.90	1	48	G	Tob
20 43.8	+39 28	SEI1230		1983.674	123.7	25.91	1	48	G	Tob
20 44.5	+28 56	MLB 710		1983.674	180.5	7.34	1	48	G	Tob
20 44.7	+41 31	MLB 25		1983.674	208.1	7.02	1	48	G	Tob
20 44.8	+30 22	AG 410		1983.674	186.1	19.08	1	48	G	Tob
20 45.2	+35 31	SEI1237		1983.674	272.1	26.01	1	48	G	Tob
20 45.7	+36 47	AG 265		1983.674	209.2	7.17	1	48	G	Tob
20 46.2	+35 46	SEI1243		1983.674	204.1	16.04	1	48	G	Tob
20 46.6	+34 52	SEI1246		1983.674	56.0	18.88	1	48	G	Tob
20 46.6	+34 52	SEI1245		1983.674	184.5	22.95	1	48	G	Tob
20 46.7	+20 44	HJ 2999		1983.614	219.1	10.07	1	48	G	Tob
20 46.7	+20 44	TOB 197	AC	1983.614	272.0	18.63	1	48	G	Tob
20 47.0	+31 56	GYL 71		1983.455	48.7	23.95	1	48	G	Tob
20 47.6	+38 39	SEI1249		1983.674	69.3	27.38	1	48	G	Tob
20 47.6	+38 12	SEI1250		1983.674	19.0	16.97	1	48	G	Tob
20 47.8	+25 19	BUP 218	AD	1983.721	251.4	154.98	1	48	G	Tob
20 48.1	+35 54	SEI1252		1983.674	117.2	16.89	1	48	G	Tob
20 48.1	+27 53	ES 510		1983.537	333.0	43.09	1	48	G	Tob
20 48.4	+40 02	SEI1255		1983.674	338.8	27.73	1	48	G	Tob
20 48.5	+36 08	SEI1253		1983.674	83.0	24.40	1	48	G	Tob
20 48.6	+40 00	TOB 198		1983.674	93.4	18.84	1	48	G	Tob
20 48.9	+35 03	SEI1257		1983.674	217.4	17.56	1	48	G	Tob
20 48.9	+34 49	SEI1258		1983.674	350.9	25.00	1	48	G	Tob
20 49.0	+34 51	SEI1259		1983.674	89.5	15.15	1	48	G	Tob
20 49.1	+32 30	GYL 70		1983.455	187.9	59.03	1	48	G	Tob
20 49.3	+39 23	SEI1263		1983.674	93.6	24.48	1	48	G	Tob
20 49.3	+33 14	ES 31	AC	1983.455	142.0	18.74	1	48	G	Tob
20 50.0	+36 40	TOB 199		1983.674	113.0	19.12	1	48	G	Tob
20 50.2	+36 42	SEI1270		1983.674	211.6	22.93	1	48	G	Tob
20 50.6	+35 52	SEI1273		1983.614	159.2	24.72	1	48	G	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
20 50.7	+38 07	SEI1275		1983.674	191.9	21.04	1	48	G	Tob
20 50.9	+38 55	SEI1278		1983.674	139.2	25.50	1	48	G	Tob
20 51.4	+45 19	ARG 40		1983.674	250.3	9.21	1	48	G	Tob
20 51.9	+39 11	SEI1283		1983.674	1.3	22.85	1	48	G	Tob
20 51.9	+33 27	GYL 26		1983.674	353.3	28.41	1	48	G	Tob
20 52.1	+36 57	SEI1285		1983.674	298.7	26.29	1	48	G	Tob
20 52.2	+35 13	HO 145		1983.674	295.2	16.61	1	48	G	Tob
20 52.5	+32 46	GYL 39		1983.455	81.1	16.40	1	48	G	Tob
20 52.9	+31 54	GYL 40		1983.455	21.2	22.83	1	48	G	Tob
20 53.1	+39 40	SEI1292		1983.674	204.5	24.41	1	48	G	Tob
20 53.3	+62 09	BUP 219		1983.674	308.7	104.88	1	48	G	Tob
20 53.3	+37 40	SEI1294		1983.674	27.2	23.86	1	48	G	Tob
20 53.5	+31 56	GYL 41		1983.674	206.0	36.49	1	48	G	Tob
20 53.7	+28 03	HJ 1589		1983.674	323.6	10.81	1	48	G	Tob
20 54.4	+37 04	SEI1305		1983.674	148.0	22.82	1	48	G	Tob
20 53.8	+36 22	SEI1302		1983.674	46.8	25.24	1	48	G	Tob
20 54.4	+36 48	SEI1306		1983.674	305.9	16.63	1	48	G	Tob
20 54.6	+39 14	MLB 780		1983.674	61.4	4.7	1	48	G	Tob
20 55.2	+39 15	MLB 782		1983.699	341.6	8.34	1	48	G	Tob
20 55.2	+39 15	SEI1313	AC	1983.699	258.7	27.47	1	48	G	Tob
20 55.3	+39 44	SEI1315		1983.677	280.6	28.57	1	48	G	Tob
20 55.4	+37 08	SEI1314		1983.614	178.9	18.49	1	48	G	Tob
20 55.5	+47 22	TOB 201		1983.452	83.7	19.75	1	48	G	Tob
20 55.5	+47 22	TOB 201	AC	1983.452	147.1	13.84	1	48	G	Tob
20 55.5	+47 22	TOB 201	AD	1983.452	116.1	18.90	1	48	G	Tob
20 55.5	+47 22	TOB 201	CD	1983.452	70.6	9.94	1	48	G	Tob
20 55.6	+39 12	SEI1319		1983.614	78.	27.48	1	48	G	Tob
20 55.6	+39 01	HJ 1596		1983.614	295.8	18.13	1	48	G	Tob
20 55.8	+47 22	TOB 200		1983.452	91.5	11.19	1	48	G	Tob
20 55.9	+32 06	STT 421		1983.455	193.8	35.08	1	48	G	Tob
20 56.0	+36 43	SEI1320		1983.614	64.5	13.37	1	48	G	Tob
20 56.1	+36 49	SEI1321		1983.614	95.8	22.45	1	48	G	Tob
20 56.2	+36 16	TOB 202		1983.614	179.0	18.02	1	48	G	Tob
20 56.2	+36 14	SEI1323		1983.614	166.7	20.70	1	48	G	Tob
20 56.3	+44 47	ES 675		1983.677	272.1	95.64	1	48	G	Tob
20 56.3	+36 34	SEI1324		1983.614	91.0	20.94	1	48	G	Tob
20 56.3	+32 47	GYL 27		1983.455	183.5	24.19	1	48	G	Tob
20 56.5	+44 47	TOB 203		1983.677	329.4	15.40	1	48	G	Tob
20 56.6	+39 32	SEI1325		1983.614	138.9	27.63	1	48	G	Tob
20 56.8	+42 54	ENG 77	CD	1983.677	356.2	91.20	1	48	G	Tob
20 57.5	+36 43	SEI1329		1983.677	30.6	25.03	1	48	G	Tob
20 57.9	+36 41	SEI1335		1983.614	25.1	19.09	1	48	G	Tob
20 58.2	+37 06	SEI1339		1983.614	260.1	12.32	1	48	G	Tob
20 58.2	+37 06	TOB 204		1983.614	89.3	10.01	1	48	G	Tob
20 58.6	+38 56	SEI1341		1983.614	208.8	28.78	1	48	G	Tob
20 58.9	+39 31	SEI1348		1983.677	295.6	26.88	1	48	G	Tob
20 59.0	+36 55	SEI1347		1983.614	125.3	18.23	1	48	G	Tob
20 59.1	+39 32	TOB 205		1983.677	203.5	14.66	1	48	G	Tob
20 59.1	+35 42	SEI1345		1983.614	172.2	19.99	1	48	G	Tob
20 59.2	+39 41	SEI1351		1983.677	257.9	17.97	1	48	G	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
20 59.2	+39 41	TOB 206	AC	1983.677	71.2	37.86	1	48	G	Tob
20 59.3	+39 25	TOB 207		1983.614	228.4	21.83	1	48	G	Tob
20 59.5	+39 23	SEI1357		1983.677	90.0	14.11	1	48	G	Tob
20 59.6	+32 16	GYL 43		1983.455	7.7	30.27	1	48	G	Tob
20 59.9	+36 12	SEI1359		1983.614	108.7	14.73	1	48	G	Tob
21 00.0	+36 55	SEI1360		1983.614	44.2	24.06	1	48	G	Tob
21 00.0	+36 55	TOB 208	AC	1983.614	233.3	30.13	1	48	G	Tob
21 00.1	+49 11	HJ 1604		1983.614	140.8	29.31	1	48	G	Tob
21 00.3	+35 43	SEI1361		1983.614	280.6	20.65	1	48	G	Tob
21 00.6	+54 32	HJ 1605	AD	1983.614	218.8	207.24	1	48	G	Tob
21 00.7	+33 53	BUP 222	AE	1983.614	88.9	810.54	1	48	G	Tob
21 00.9	+39 00	SEI1365		1983.614	265.4	18.20	1	48	G	Tob
21 01.0	+36 47	SEI1367		1983.614	247.5	20.50	1	48	G	Tob
21 01.1	+33 24	GYL 45		1983.455	243.8	.	1	48	G	Tob
21 01.4	+39 48	SEI1370		1983.677	142.8	20.95	1	48	G	Tob
21 02.4	+34 09	GYL 29		1983.614	166.7	11.49	1	48	G	Tob
21 02.5	+38 44	SEI1374		1983.614	105.0	16.68	1	48	G	Tob
21 02.9	+35 54	J 1078	AC	1983.614	137.5	24.22	1	48	G	Tob
21 03.5	+29 06	BU 445	AE	1983.455	218.5	103.32	1	48	G	Tob
21 04.0	+28 41	HJ 1609		1983.455	27.4	7.37	1	48	G	Tob
21 04.2	+35 30	SEI1388		1983.614	209.6	22.11	1	48	G	Tob
21 04.4	+35 51	SEI1390		1983.614	344.2	17.20	1	48	G	Tob
21 05.0	+35 59	SEI1395		1983.614	132.0	20.79	1	48	G	Tob
21 05.7	+34 07	TOB 210		1983.614	59.3	18.96	1	48	G	Tob
21 05.8	+37 26	SEI1399		1983.614	31.4	23.90	1	48	G	Tob
21 05.8	+36 33	SEI1397		1983.614	344.4	22.00	1	48	G	Tob
21 05.8	+36 10	SEI1398		1983.614	35.2	30.40	1	48	G	Tob
21 05.9	+32 32	GYL 48		1983.797	179.5	30.51	1	48	G	Tob
21 06.1	+44 48	ROE 45		1983.677	286.0	134.40	1	48	G	Tob
21 06.1	+44 48	ROE 45	AD	1983.677	241.1	130.62	1	48	G	Tob
21 06.1	+37 06	SEI1400		1983.614	136.5	27.24	1	48	G	Tob
21 06.1	+35 58	SEI1401		1983.614	332.3	10.37	1	48	G	Tob
21 06.4	+36 43	SEI1403		1983.614	129.4	11.42	1	48	G	Tob
21 06.6	+36 45	SEI1404		1983.614	306.9	23.94	1	48	G	Tob
21 06.6	+36 45	TOB 209	BC	1983.614	322.7	19.29	1	48	G	Tob
21 06.7	+46 31	SMA 125		1983.452	87.6	22.26	1	48	G	Tob
21 06.8	+34 08	STF2760	AC	1983.614	150.5	61.38	1	48	G	Tob
21 06.9	+38 45	STF2758	AD	1983.614	294.4	294.9	1	48	G	Tob
21 06.9	+38 45	STF2758	AE	1983.614	359.4	288.3	1	48	G	Tob
21 07.0	+41 25	BU 988	AC	1983.677	17.7	9.73	1	48	G	Tob
21 07.0	+28 16	HJ 1611		1983.797	278.9	10.10	1	48	G	Tob
21 07.5	+45 15	HJ 1615		1983.677	277.6	14.10	1	48	G	Tob
21 07.8	+34 21	ABH 141	AD	1983.614	222.1	84.24	1	48	G	Tob
21 07.9	+37 01	SEI1409		1983.614	132.6	26.56	1	48	G	Tob
21 08.2	+36 28	SEI1410		1983.614	167.3	20.13	1	48	G	Tob
21 08.5	+36 08	SEI1413		1983.614	112.3	29.70	1	48	G	Tob
21 08.7	+37 19	SEI1415		1983.614	255.2	31.35	1	48	G	Tob
21 08.7	+35 51	SEI1414		1983.614	30.9	11.07	1	48	G	Tob
21 08.7	+35 51	TOB 211	AC	1983.614	356.9	24.47	1	48	G	Tob
21 08.9	+48 15	ARG 42		1983.614	59.7	21.30	1	48	G	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
21 09.4	+37 16	SEI1419		1983.614	147.0	14.06	1	48	G	Tob
21 09.9	+36 59	SEI1422		1983.614	332.3	20.35	1	48	G	Tob
21 10.1	+36 20	SEI1424		1983.614	60.5	26.11	1	48	G	Tob
21 10.4	+37 05	SEI1427		1983.614	163.0	25.68	1	48	G	Tob
21 10.4	+32 15	SEI1425		1983.797	33.3	21.59	1	48	G	Tob
21 10.4	+32 15	TOB 212	AC	1983.797	83.4	23.10	1	48	G	Tob
21 11.7	+36 21	SEI1439		1983.614	164.5	24.79	1	48	G	Tob
21 11.7	+36 19	TOB 213		1983.614	349.	16.05	1	48	G	Tob
21 12.1	+35 39	SEI1441		1983.614	157.1	13.9	1	48	G	Tob
21 12.5	+37 20	HJ 1623	A-BC	1983.614	150.4	22.33	1	48	G	Tob
21 12.9	+37 17	SEI1449		1983.614	113.4	14.54	1	48	G	Tob
21 12.9	+36 19	SEI1450		1983.614	170.0	18.32	1	48	G	Tob
21 13.0	+36 48	SEI1452		1983.614	337.1	25.69	1	48	G	Tob
21 13.2	+32 28	SEI1451		1983.797	250.7	27.84	1	48	G	Tob
21 13.3	+38 03	TOB 214		1983.614	212.6	23.99	1	48	G	Tob
21 13.4	+34 04	SLE 371		1983.614	272.6	13.29	1	48	G	Tob
21 14.3	+36 27	SEI1459		1983.614	184.2	14.91	1	48	G	Tob
21 14.8	+36 31	SEI1468		1983.614	242.4	18.74	1	48	G	Tob
21 14.8	+32 38	TOB 218		1983.797	294.1	21.69	1	48	G	Tob
21 14.8	+32 16	SEI1463		1983.797	125.8	26.79	1	48	G	Tob
21 15.1	+37 41	SEI1474		1983.614	22.2	22.27	1	48	G	Tob
21 15.1	+37 16	SEI1472		1983.614	96.3	23.27	1	48	G	Tob
21 15.1	+36 34	SEI1473		1983.614	99.7	22.50	1	48	G	Tob
21 15.1	+33 13	TOB 217		1983.797	267.8	16.25	1	48	G	Tob
21 15.5	+36 13	SEI1480		1983.614	341.2	15.47	1	48	G	Tob
21 15.5	+33 13	TOB 215		1983.797	230.7	16.17	1	48	G	Tob
21 15.6	+36 00	SEI1479		1983.797	91.0	26.79	1	48	G	Tob
21 15.6	+33 15	TOB 216		1983.797	135.8	14.22	1	48	G	Tob
21 15.7	+32 35	HJ 1628		1983.797	258.1	16.36	1	48	G	Tob
21 15.7	+32 35	HJ 1628		1983.797	258.8	16.42	1	48	G	Tob
21 16.8	+40 19	TOB 219		1983.677	212.5	34.98	1	48	G	Tob
21 16.9	+41 40	POP 186		1983.797	300.5	9.00	1	48	G	Tob
21 16.9	+41 40	POP 186	AC	1983.677	128.5	61.68	1	48	G	Tob
21 16.9	+39 06	SEI1486		1983.797	321.8	23.58	1	48	G	Tob
21 17.0	+40 20	SEI1487		1983.677	238.3	20.99	1	48	G	Tob
21 17.2	+39 36	SEI1490		1983.677	105.0	21.68	1	48	G	Tob
21 17.4	+40 20	SEI1492		1983.677	248.0	24.82	1	48	G	Tob
21 18.1	+28 25	HJ 1632		1983.797	42.0	8.64	1	48	G	Tob
21 18.3	+34 56	SLE 384	AD	1983.677	188.5	43.18	1	48	G	Tob
21 18.4	+39 30	SEI1496		1983.677	355.3	17.31	1	48	G	Tob
21 19.0	+39 45	STT 434		1983.614	121.2	24.66	1	48	G	Tob
21 19.0	+39 05	SEI1498		1983.614	93.2	25.87	1	48	G	Tob
21 19.0	+39 05	TOB 220	BC	1983.614	74.0	14.31	1	48	G	Tob
21 19.1	+39 44	SEI1501		1983.39	242.4	29.39	1	48	G	Tob
21 19.5	+42 53	FOX 259		1983.614	309.5	11.73	1	48	G	Tob
21 21.5	+54 34	ROE 91	AD	1983.518	276.0	87.42	1	48	G	Tob
21 21.5	+40 02	SEI1511		1983.614	283.2	27.85	1	48	G	Tob
21 21.5	+37 19	ROE 24		1983.614	168.5	9.43	1	48	G	Tob
21 21.5	+37 19	ROE 24	A-Ca	1983.614	266.7	80.52	1	48	G	Tob
21 24.6	+48 01	HJ 1644		1983.679	112.4	26.98	1	48	G	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
21 24.8	+50 15	HJ 1645		1983.679	42.5	9.35	1	48	G	Tob
21 25.2	+37 08	SEI1513		1983.540	90.3	14.39	1	48	G	Tob
21 25.8	+33 29	GYL 56		1983.797	5.9	15.78	1	48	G	Tob
21 27.1	+36 27	SEI1517		1983.540	79.9	15.91	1	48	G	Tob
21 31.7	+33 02	GYL 63		1983.797	304.5	16.27	1	48	G	Tob
21 32.5	+44 36	POP 136	A-BC	1983.674	251.	24.73	1	48	G	Tob
21 33.1	+37 26	SEI1525		1983.540	99.2	14.77	1	48	G	Tob
21 33.4	+30 58	KU 132		1983.797	256.6	53.83	1	48	G	Tob
21 33.6	+33 25	TOB 222		1983.797	122.3	20.45	1	48	G	Tob
21 33.6	+33 25	TOB 222	AC	1983.797	338.5	20.77	1	48	G	Tob
21 33.6	+33 25	TOB 222	AD	1983.797	70.5	26.69	1	48	G	Tob
21 34.8	+33 04	GYL 61		1983.797	190.5	46.15	1	48	G	Tob
21 35.3	+52 10	HU 594	AC	1983.518	87.3	58.92	1	48	G	Tob
21 36.3	+26 17	PHL 1		1983.847	308.9	12.45	1	48	G	Tob
21 37.8	+37 39	SEI1527		1983.540	331.5	25.88	1	48	G	Tob
21 38.2	+35 14	SEI1528		1983.540	64.1	23.02	1	48	G	Tob
21 39.2	+32 41	ES 2320		1983.797	194.9	11.90	1	48	G	Tob
21 39.6	+36 50	SEI1530		1983.540	160.4	19.50	1	48	G	Tob
21 40.1	+48 24	HJ 1681		1983.679	116.1	7.36	1	48	G	Tob
21 40.9	+31 22	AG 275		1983.797	12.4	10.34	1	48	G	Tob
21 42.6	+42 26	STF2820		1983.674	235.8	16.28	1	48	G	Tob
21 42.6	+42 26	BU 1505	AC	1983.674	198.9	33.04	1	48	G	Tob
21 44.1	+28 45	STF2822	BD	1983.797	44.5	197.40	1	48	G	Tob
21 44.2	+26 31	BUP 230	AC	1983.847	260.4	570.54	1	48	G	Tob
21 44.2	+26 31	BUP 230	AD	1983.847	288.7	438.96	1	48	G	Tob
21 44.2	+26 31	BUP 230	CD	1983.847	31.4	277.32	1	48	G	Tob
21 45.4	+39 55	SEI1534		1983.674	190.7	27.94	1	48	G	Tob
21 46.5	+22 10	HO 465		1983.847	244.7	42.76	1	48	G	Tob
21 46.9	+32 29	GYL 65		1983.799	28.8	60.36	1	48	G	Tob
21 47.8	+57 43	FOX 263		1983.655	301.6	16.03	1	48	G	Tob
21 49.2	+50 31	STF2832	AC	1983.679	320.2	46.02	1	48	G	Tob
21 49.2	+50 31	STF2832	BC	1983.679	334.3	51.34	1	48	G	Tob
21 49.2	+43 26	PKO 17		1983.674	150.9	13.57	1	48	G	Tob
21 49.5	+53 49	HJ 3062		1983.521	120.1	23.06	1	48	G	Tob
21 50.1	+31 51	BU 692	AB-C	1983.797	294.0	41.19	1	48	G	Tob
21 52.9	+39 01	SEI1542		1983.540	171.9	29.46	1	48	G	Tob
21 55.5	+52 32	ABH 154	AB-G	1983.518	106.8	111.0	1	48	G	Tob
21 55.6	+35 05	SEI1544		1983.540	216.4	21.40	1	48	G	Tob
21 55.8	+37 16	HO 174		1983.540	314.7	8.53	1	48	G	Tob
21 55.8	+37 16	HO 174	AC	1983.540	227.1	163.68	1	48	G	Tob
21 58.2	+44 28	SMA 154		1983.674	160.5	10.65	1	48	G	Tob
21 58.4	+69 30	MLB 308		1983.682	162.7	33.81	1	48	G	Tob
21 59.2	+41 58	A 406		1983.674	4.0	33.95	1	48	G	Tob
21 59.6	+52 23	HU 775	AC	1983.518	173.1	15.36	1	48	G	Tob
21 59.8	+35 15	J 2704	AC	1983.540	291.4	19.52	1	48	G	Tob
21 59.8	+35 15	J 2704	AC	1983.540	291.3	19.58	1	48	G	Tob
22 00.5	+64 45	SMA 157		1983.862	81.2	20.13	1	48	G	Tob
22 00.6	+54 11	STF2852		1983.518	186.2	8.24	1	48	G	Tob
22 01.3	+45 15	A 780	AC	1983.674	94.0	66.00	1	48	G	Tob
22 03.8	+64 38	STF2863		1983.682	276.0	7.84	1	48	G	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
22 03.9	+59 49	STT 461	DE	1983.655	346.2	133.62	1	48	G	Tob
22 04.2	+35 07	SEI1554		1983.540	292.8	16.26	1	48	G	Tob
22 04.3	+51 22	TOB 223		1983.677	181.5	14.97	1	48	G	Tob
22 05.1	+48 05	HDS3135		1983.674	174.6	12.25	1	48	G	Tob
22 05.3	+46 29	HJ 1725		1983.677	78.2	29.48	1	48	G	Tob
22 05.6	+36 20	TOB 224		1983.540	78.1	16.20	1	48	G	Tob
22 06.4	+47 16	ES 532		1983.677	247.9	8.43	1	48	G	Tob
22 06.5	+28 06	MLB 722	AC	1982.797	325.2	31.64	1	48	G	Tob
22 06.9	+33 35	ES 385	AC	1982.797	0.9	33.05	1	48	G	Tob
22 06.9	+33 35	TOB 225	AD	1982.797	6.4	122.28	1	48	G	Tob
22 08.4	+61 05	ES 1923		1984.655	339.7	27.10	1	48	G	Tob
22 08.4	+61 05	ES 1923	AD	1984.655	13.9	25.60	1	48	G	Tob
22 09.3	+44 51	HJ 1735		1983.674	108.8	26.45	1	48	G	Tob
22 10.0	+33 43	GYL 72		1983.540	165.4	22.19	1	48	G	Tob
22 10.3	+68 12	MLB1097		1983.682	5.1	12.21	1	48	G	Tob
22 10.3	+47 58	ABH 160	AE	1983.677	120.5	67.26	1	48	G	Tob
22 10.7	+33 22	TOB 226		1982.797	337.1	18.42	1	48	G	Tob
22 13.4	+33 35	TOB 227		1983.540	261.8	27.29	1	48	G	Tob
22 15.2	+49 53	STF2890		1983.677	10.5	9.43	1	48	G	Tob
22 15.2	+49 53	STF2890	AC	1983.677	276.8	72.72	1	48	G	Tob
22 15.9	+54 40	BU 377		1983.518	62.0	37.87	1	48	G	Tob
22 18.4	+49 40	ES 534	AC	1983.677	69.8	49.02	1	48	G	Tob
22 20.7	+24 57	STF2895	AC	1983.775	142.2	120.96	1	48	G	Tob
22 20.7	+24 57	STF2895	CD	1983.775	78.0	11.89	1	48	G	Tob
22 23.4	+23 00	ROE 129		1983.775	207.1	89.16	1	48	G	Tob
22 23.7	+40 54	WEI 38	AC	1983.674	353.0	38.42	1	48	G	Tob
22 23.7	+40 54	WEI 38	BC	1983.674	343.9	35.72	1	48	G	Tob
22 24.8	+28 33	MLB 543	AC	1982.797	208.3	21.01	1	48	G	Tob
22 26.5	+38 37	HO 185	AC	1983.542	81.5	88.98	1	48	G	Tob
22 26.6	+50 19	HJ 1766		1983.677	263.7	12.65	1	48	G	Tob
22 27.4	+57 19	TOB 228		1983.518	345.0	21.06	1	48	G	Tob
22 27.4	+57 19	TOB 228	AC	1983.518	105.5	12.03	1	48	G	Tob
22 29.5	+73 21	LDS1988		1983.679	78.0	243.84	1	48	G	Tob
22 30.7	+37 29	ES 2072		1983.542	321.2	12.97	1	48	G	Tob
22 32.4	+60 15	HJ 1782	AC	1983.652	91.0	56.51	1	48	G	Tob
22 34.6	+29 44	HJ 1785		1982.797	171.1	13.96	1	48	G	Tob
22 35.7	+56 52	HJ 1791		1983.518	59.4	16.91	1	48	G	Tob
22 36.3	+29 45	AG 423		1982.797	154.2	23.50	1	48	G	Tob
22 37.3	+53 21	SMA 175		1983.518	56.5	11.23	1	48	G	Tob
22 38.2	+55 34	ES 1025		1983.518	325.2	43.42	1	48	G	Tob
22 38.3	+46 59	HJ 1794		1983.677	317.9	16.20	1	48	G	Tob
22 39.6	+50 07	HJ 1797		1983.677	125.2	14.61	1	48	G	Tob
22 39.8	+48 43	ES 843		1983.677	208.5	8.93	1	48	G	Tob
22 40.1	+32 01	CHE 337		1982.797	234.5	14.44	1	48	G	Tob
22 40.6	+29 33	CHE 345		1982.797	146.6	22.07	1	48	G	Tob
22 40.8	+52 59	SMA 178		1983.518	178.8	15.44	1	48	G	Tob
22 41.6	+29 47	CHE 366		1982.797	6.8	21.89	1	48	G	Tob
22 41.7	+30 47	CHE 369		1982.797	149.7	17.66	1	48	G	Tob
22 41.7	+30 47	CHE 369	AC	1982.797	279.3	24.02	1	48	G	Tob
22 42.1	+31 52	CHE 375		1982.797	254.4	19.86	1	48	G	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
22 42.7	+32 54	CHE 385		1982.797	240.9	38.41	1	48	G	Tob
22 43.5	+38 13	DOB 16		1983.542	80.4	23.53	1	48	G	Tob
22 44.0	+30 47	CHE 401		1982.797	256.7	17.37	1	48	G	Tob
22 44.2	+31 52	CHE 404		1982.797	298.8	29.89	1	48	G	Tob
22 44.2	+31 52	CHE 404	AC	1982.797	242.3	36.90	1	48	G	Tob
22 44.4	+32 52	CHE 408		1982.797	22.1	34.44	1	48	G	Tob
22 45.3	+40 02	AG 287		1984.899	201.0	16.47	1	48	G	Tob
22 45.7	+38 14	DOB 17		1984.899	354.1	84.60	1	48	G	Tob
22 46.1	+65 18	BLL 57		1983.679	240.9	150.66	1	48	G	Tob
22 47.4	+32 52	CHE 432		1982.797	9.6	22.04	1	48	G	Tob
22 47.5	+58 33	BU 1145	AC	1984.655	180.3	21.61	1	48	G	Tob
22 49.0	+68 34	STF2947	BC	1983.679	204.9	117.36	1	48	G	Tob
22 51.0	+30 02	MLB 586	AC	1982.882	350.5	47.04	1	48	G	Tob
22 53.0	+31 40	HJ 972		1982.797	206.9	27.99	1	48	G	Tob
22 54.2	+28 01	STF2952	AC	1982.882	244.5	165.12	1	48	G	Tob
22 54.4	+55 38	HJ 1830	AC	1983.518	80.9	16.41	1	48	G	Tob
22 55.1	+23 31	POU5758		1983.674	233.8	19.60	1	48	G	Tob
22 55.8	+45 08	SMA 181		1983.674	280.1	9.97	1	48	G	Tob
23 00.4	+41 07	HJ 1839		1983.674	304.8	14.70	1	48	G	Tob
23 01.6	+69 12	OL 224		1983.674	47.6	6.97	1	48	G	Tob
23 04.5	+31 23	ES 396		1983.674	302.2	31.70	1	48	G	Tob
23 08.7	+36 27	HJ 5531		1983.674	66.6	.	1	48	G	Tob
23 09.7	+59 20	S 823	CD	1983.674	310.3	276.00	1	48	G	Tob
23 10.3	+32 29	HJ 5532	AB-C	1983.674	76.6	58.15	1	48	G	Tob
23 11.2	+29 19	KU 137		1982.882	89.6	33.43	1	48	G	Tob
23 12.1	+45 17	BU 1528		1983.674	191.7	33.35	1	48	G	Tob
23 15.0	+35 56	ABH 168	AD	1982.803	61.3	80.58	1	48	G	Tob
23 15.9	+52 58	HJ 3181		1983.677	19.1	22.87	1	48	G	Tob
23 15.9	+52 58	HJ 3181	AC	1983.677	48.7	154.74	1	48	G	Tob
23 15.9	+27 29	HJ 1862		1983.778	235.8	16.21	1	48	G	Tob
23 21.8	+42 26	CHE 436		1983.674	336.4	30.59	1	48	G	Tob
23 22.3	+42 04	CHE 437		1984.647	188.0	31.19	1	48	G	Tob
23 22.3	+42 04	CHE 437	AC	1984.647	45.2	21.12	1	48	G	Tob
23 22.5	+42 11	CHE 438		1984.647	268.6	12.65	1	48	G	Tob
23 22.6	+41 50	CHE 440		1983.674	125.7	27.46	1	48	G	Tob
23 22.7	+42 55	CHE 441		1984.647	40.9	47.94	1	48	G	Tob
23 23.0	+42 18	CHE 444		1983.674	149.8	36.48	1	48	G	Tob
23 23.4	+42 48	CHE 445		1984.647	254.1	30.66	1	48	G	Tob
23 23.4	+42 34	CHE 446		1983.674	190.0	14.97	1	48	G	Tob
23 23.4	+42 24	CHE 447		1983.674	286.0	26.97	1	48	G	Tob
23 24.3	+61 35	BLL 58	AC	1984.655	354.9	80.64	1	48	G	Tob
23 24.8	+62 17	H 6 24		1984.655	225.0	95.70	1	48	G	Tob
23 24.8	+62 17	H 6 24	CD	1984.655	38.3	9.23	1	48	G	Tob
23 24.9	+41 49	CHE 453		1984.655	34.2	39.52	1	48	G	Tob
23 25.0	+42 20	CHE 455		1984.655	303.0	28.94	1	48	G	Tob
23 25.5	+41 42	CHE 456		1984.655	123.1	28.66	1	48	G	Tob
23 26.0	+42 01	CHE 458		1984.647	262.2	29.68	1	48	G	Tob
23 26.3	+43 09	CHE 460		1984.647	259.6	26.87	1	48	G	Tob
23 26.4	+43 17	CHE 461		1984.647	330.5	15.96	1	48	G	Tob
23 26.5	+42 35	CHE 463		1984.647	309.3	50.76	1	48	G	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
23 26.7	+43 17	CHE 465		1984.647	313.3	30.03	1	48	G	Tob
23 26.8	+41 57	CHE 466		1984.647	124.8	19.36	1	48	G	Tob
23 27.0	+43 04	CHE 467		1984.647	66.7	16.74	1	48	G	Tob
23 27.2	+42 24	CHE 470		1984.647	203.8	31.87	1	48	G	Tob
23 27.6	+42 48	CHE 472		1984.647	224.0	23.32	1	48	G	Tob
23 27.7	+41 46	CHE 474		1984.647	187.2	27.29	1	48	G	Tob
23 27.8	+43 09	CHE 475		1984.647	85.0	31.64	1	48	G	Tob
23 27.9	+50 11	HJ 1884		1983.677	245.5	12.33	1	48	G	Tob
23 27.9	+42 07	CHE 478		1984.647	231.2	43.39	1	48	G	Tob
23 27.9	+42 01	CHE 480		1984.647	147.9	36.89	1	48	G	Tob
23 28.0	+60 20	SMA 199		1984.647	35.9	9.85	1	48	G	Tob
23 28.0	+43 01	CHE 481		1984.647	280.7	15.13	1	48	G	Tob
23 28.2	+42 45	CHE 484		1984.647	87.9	27.85	1	48	G	Tob
23 28.3	+25 56	BUP 237	AD	1983.778	100.3	779.04	1	48	G	Tob
23 28.5	+42 30	CHE 488		1984.647	26.3	34.45	1	48	G	Tob
23 28.8	+42 27	CHE 490		1984.647	16.8	31.26	1	48	G	Tob
23 28.8	+41 54	CHE 491		1984.647	61.4	34.52	1	48	G	Tob
23 28.8	+41 44	CHE 492		1984.647	66.7	18.82	1	48	G	Tob
23 28.9	+42 30	CHE 493		1984.647	23.5	32.56	1	48	G	Tob
23 29.0	+42 45	CHE 494	AC	1984.647	181.7	10.74	1	48	G	Tob
23 29.3	+42 48	CHE 496		1984.647	153.1	35.07	1	48	G	Tob
23 29.4	+43 01	CHE 498		1984.647	265.2	18.17	1	48	G	Tob
23 29.7	+42 06	CHE 499		1984.647	183.7	27.76	1	48	G	Tob
23 29.9	+39 10	MLB 805		1982.803	261.7	9.50	1	48	G	Tob
23 30.0	+41 50	CHE 500		1984.647	41.6	20.21	1	48	G	Tob
23 30.1	+42 15	CHE 501		1984.647	271.4	24.73	1	48	G	Tob
23 30.3	+42 39	CHE 502		1984.647	23.6	11.17	1	48	G	Tob
23 30.4	+42 38	CHE 503		1984.647	353.3	25.59	1	48	G	Tob
23 30.9	+58 25	STF3022	AC	1984.647	190.7	117.48	1	48	G	Tob
23 35.9	+51 32	FOX 274	AD	1983.690	185.0	85.26	1	48	G	Tob
23 37.5	+48 32	ES 859		1983.690	217.5	87.78	1	48	G	Tob
23 39.9	+47 33	ROE 57		1983.690	117.3	16.37	1	48	G	Tob
23 40.2	+49 49	AG 427		1983.690	247.3	18.46	1	48	G	Tob
23 40.7	+62 57	STI1195		1984.655	103.2	10.31	1	48	G	Tob
23 42.4	+49 56	HJ 1903	AC	1983.690	358.2	27.85	1	48	G	Tob
23 42.4	+33 08	ES 2398		1983.781	265.8	11.75	1	48	G	Tob
23 43.2	+54 55	ES 1048	AD	1983.677	17.7	72.60	1	48	G	Tob
23 43.4	+63 25	STI1202		1983.781	36.4	12.86	1	48	G	Tob
23 43.5	+58 05	ENG 88	Aa-B	1984.655	200.6	106.98	1	48	G	Tob
23 43.5	+58 05	ENG 88	Aa-C	1984.655	144.7	166.32	1	48	G	Tob
23 43.5	+58 05	ENG 88	Aa-E	1984.655	214.9	159.96	1	48	G	Tob
23 43.5	+58 05	ENG 88	Aa-F	1984.655	197.3	220.98	1	48	G	Tob
23 43.5	+58 05	TOB 231	Aa-G	1984.655	139.7	191.94	1	48	G	Tob
23 44.8	+56 27	BAR 64		1983.778	318.7	352.68	1	48	G	Tob
23 46.1	+60 28	STF3037	BC	1983.781	186.5	27.12	1	48	G	Tob
23 48.2	+57 54	MLB 149	AC	1984.655	164.7	12.42	1	48	G	Tob
23 49.5	+55 47	HJ 1910		1983.778	249.2	15.77	1	48	G	Tob
23 55.3	+51 44	ES 2735		1983.778	93.1	12.73	1	48	G	Tob
23 55.3	+51 44	ES 2735	AC	1983.778	233.4	17.58	1	48	G	Tob
23 57.0	+49 29	HJ 1920		1983.707	257.9	18.36	1	48	G	Tob

RA	Dec	Pair	Comp	Epoch	PA	Sep	n	Tel.	Meth.	Obs
23 57.3	+61 02	STT 512	AC	1984.655	82.8	364.86	1	48	G	Tob
23 58.1	+24 20	STF3048	AC	1983.778	263.3	36.41	1	48	G	Tob
23 59.0	+53 15	HLD 59	AC	1983.778	311.5	17.65	1	48	G	Tob

References

1. Tobal, T, Webb Society Double Star Section Circulars **13**, p. 39, 2004

MEASUREMENT OF THE POSITIONS OF MILBURN (MLB) PAIRS FROM SKY SURVEYS - II

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Introduction

This paper is a continuation of the work published in Double Star Section Circular No. 14 [1] looking at recovering and providing precise positions for pairs found by William Milburn. The current analysis covers the Washington Double Star (WDS) catalogue from 08149+3823MLB 837 to 22507+4005MLB 966. Using Aladin, the sky around the WDS position was searched for an appropriate pair matching the WDS data.

WDS data for Milburn pairs

WDS 2000	Name	Epochs	N	PAs	Seps	Mags	This paper	Note
08149+3823	MLB 837	1933 1933	1	81 81	5.5 5.5	11.0 12.0	Not found	
12307+6404	MLB 465	1926 2003	4	156 157	2.5 2.0	9.5 11.7	Not identified	
13408+3644	MLB 934	1934 1934	1	21 21	1.8 1.8	10.0 12.0	Not identified	
17469+3555	MLB 936	1934 1934	1	81 81	2.2 2.2	11.0 12.1	17 46 52.76 +35 55 28.9	%
18536+2823	MLB 692AB	1931 1931	1	299 299	2.4 2.4	11.0 13.0	Not identified	
18536+2823	MLB 692AC	1931 1931	1	300 300	8.0 8.0	11.0 13.5	Not identified	
18538+6509	MLB 215	1921 1921	1	272 272	6.8 6.8	10.5 10.6	Not identified	
19009+3714	MLB 758AB	1932 1932	1	27 27	6.4 6.4	9.6 12.7		
19009+3714	MLB 758AC	1932 1932	1	147 147	7.8 7.8	9.6 10.0	19 00 51.88 +37 14 03.6 Note 1	†
19210+3931	MLB 861	1933 1933	1	114 114	5.6 5.6	9.5 10.0	Not identified	
19346+3850	MLB 940	1934 1934	1	194 194	2.0 2.0	10.0 12.0	19 34 36.91 +38 50 02.1	%
19371+6624	MLB 217	1921 1997	2	217 229	2.5 2.3	9.9 11.5	19 36 49.63 +66 23 19.4	%
19388+3931	MLB 942	1934 1934	1	149 149	3.8 3.8	11.5 12.5	19 38 44.09 +39 31 09.9	%
19412+4058	MLB 875	1933 1933	1	189 189	5.4 5.4	10.0 10.1	19 41 07.61 +40 58 03.7	
19421+2852	MLB 527	1927 1927	1	176 176	5.5 5.5	10.4 10.7	19 42 03.21 +28 53 36.4	%
19470+3926	MLB 979	1935 1978	2	206 25	2.2 3.1	10.0 10.2	19 47 00.99 +39 25 44.0	†
19474+3926	MLB 980	1935 1980	2	25 31	3.6 4.5	9.8 10.5	19 47 23.08 +39 26 14.4	%
19503+6857	MLB 358	1924 1924	1	245 245	3.6 3.6	11.0 13.0	19 50 28.92 +68 57 29.7	†
19526+2846	MLB 475	1926 1926	1	293 293	2.6 2.6	10.2 13.7	Not identified	
19530+3936	MLB 944	1934 1934	1	152 152	7.3 7.3	9.5 10.7	19 52 56.23 +39 35 02.7	†
19530+3856	MLB 767	1932 1932	1	120 120	7.3 7.3	10.2 10.5	19 53 01.71 +38 54 57.1	%
19533+3935	MLB 945	1934 1997	3	95 91	1.9 1.7	9.8 11.2	Not found	
19534+3934	MLB 946	1934 1934	1	221 221	4.9 4.9	10.5 10.5	19 53 22.50 +39 33 17.8	%
19535+3933	MLB 947	1934 1934	1	259 259	6.0 6.0	10.0 12.0	19 53 28.41 +39 31 54.2	%
19558+3918	MLB 877	1933 1933	1	35 35	4.6 4.6	11.5 12.5	19 55 47.18 +39 17 39.3	%

WDS 2000	Name	Epochs	N	PAs	Seps	Mags	This paper	Note
19570+3836	MLB 948	1934 1934	1	6 6	4.1 4.1	10.7 11.7	19 57 00.54 +38 36 08.4	%
19576+3906	MLB 981	1935 1984	2	56 38	3.7 3.6	10.3 11.2	Not found	
20012+5909	MLB 82	1918 1918	1	11 11	5.1 5.1	11.2 11.7	20 00 47.85 +59 08 12.8	†
20039+6754	MLB 295	1923 1923	1	305 305	7.3 7.3	10.0 13.0	Not found	
20067+2856	MLB 704	1928 1931	2	107 117	2.8 2.7	11.6 13.5	20 06 41.15 +28 56 44.7	%
20085+3936	MLB 768	1932 1932	1	109 109	4.4 4.4	10.0 10.1	20 08 30.81 +39 35 36.2	%
20112+3854	MLB 950	1934 1934	1	193 193	3.2 3.2	10.0 13.0	Not found	
20128+2725	MLB 706	1931 1997	2	172 173	1.8 2.1	10.2 13.2	Not found	
20156+7051	MLB 418	1925 1925	1	48 48	3.8 3.8	10.5 11.2	20 15 39.58 +70 50 42.7	%
20173+3834	MLB 951	1934 1934	1	314 314	3.3 3.3	10.5 12.5	20 17 16.46 +38 33 55.3	%
20174+3855	MLB 952	1934 1934	1	66 66	5.4 5.4	10.0 10.5	Not found	
20229+3829	MLB 773	1932 1932	1	290 290	7.5 7.5	10.5 11.7	Not found	
20253+4003	MLB 22	1917 1990	5	225 228	5.1 5.5	10.3 11.6	20 25 21.35 +40 04 22.5	%
20351+3914	MLB 777	1932 1932	1	187 187	5.3 5.3	11.0 11.1	20 35 04.63 +39 13 12.7	%
20382+3938	MLB 778	1932 1932	1	310 310	4.7 4.7	10.0 11.5	20 38 11.94 +39 38 25.6	%x
20398+5844	MLB 85	1918 1918	1	134 134	6.3 6.3	9.9 11.8	20 39 54.84 +58 45 34.2	%
20402+3953	MLB 885	1933 1933	1	53 53	1.8 1.8	10.0 11.0	Not found	
20458+7219	MLB 421	1925 1925	1	254 254	1.9 1.9	10.0 10.6	Not found	
20461+2916	MLB 711	1931 1931	1	40 40	4.5 4.5	9.8 12.0	20 46 03.01 +29 16 29.6	%
20464+6102	MLB 141	1919 1919	1	293 293	4.6 4.6	10.0 12.3	20 46 27.88 +61 01 05.5	%
20492+6547	MLB 267	1922 1982	2	225 228	2.3 3.5	10.0 11.0	20 49 08.99 +65 45 56.7	%
20520+4009	MLB 955	1934 1934	1	17 17	5.6 5.6	10.0 10.2	20 52 06.91 +40 08 47.4	†
20545+2736	MLB 714	1931 2004	2	207 200	3.7 4.3	9.8 10.9	20 54 28.11 +27 36 08.9	%
20549+3913	MLB 781	1932 1932	1	296 296	7.5 7.5	10.6 10.6	20 54 53.62 +39 13 12.1	%
20555+3940	MLB 783	1933 1933	1	302 302	4.6 4.6	10.0 11.0	20 55 33.12 +39 40 40.0	%
20558+3905	MLB 956	1934 1934	1	114 114	4.6 4.6	10.2 11.2	20 55 50.47 +39 05 11.2	%
20559+3922	MLB 957	1934 1934	1	128 128	2.3 2.3	11.5 12.0	Not found	
20562+2816	MLB 615	1929 1929	1	193 193	4.0 4.0	10.0 11.5	20 56 09.24 +28 16 11.6	%
21001+2801	MLB 617	1929 1929	1	336 336	5.3 5.3	10.1 13.7	21 00 04.16 +28 01 20.3	%
21001+2757	MLB 618	1929 1929	1	341 341	4.9 4.9	10.1 13.2	21 00 02.10 +27 57 27.1	%
21055+2901	MLB 536	1927 1927	1	236 236	4.7 4.7	10.5 12.5	21 05 22.68 +29 02 40.6	%
21126+3915	MLB 893	1933 1933	1	150 150	3.4 3.4	10.0 11.0	21 12 36.92 +39 14 56.3	%
21148+7003	MLB 364	1924 1924	1	64 64	4.0 4.0	9.7 11.7	21 14 51.38 +70 02 49.0	%
21169+3001	MLB 538	1927 1977	3	312 311	3.3 2.8	10.2 11.7	21 16 52.44 +30 01 26.1	%
21275+3954	MLB 984	1935 1935	1	95 95	3.1 3.1	11.7 12.7	21 27 26.13 +39 54 18.6	%
21289+3941	MLB 986	1935 1935	1	63 63	3.0 3.0	12.0 12.2	21 28 52.87 +39 41 33.3	†
21299+3928	MLB 987	1935 1935	1	259 259	7.2 7.2	10.0 10.2	21 29 53.04 +39 29 12.7	†
21305+6118	MLB 142	1919 1919	1	325 325	4.0 4.0	10.3 13.8	21 30 21.01 +61 19 11.2	%
21324+3903	MLB 988	1935 1981	2	111 119	1.9 2.1	11.0 12.3	21 32 23.52 +39 03 07.5	%
21328+3901	MLB 989	1935 2000	4	137 160	2.1 3.0	10.0 10.0	21 32 49.03 +39 00 22.1	%
21331+3938	MLB 899	1933 1935	3	41 51	3.5 3.2	10.4 10.8	Not found	
21335+6413	MLB 223	1921 1980	2	133 135	2.3 1.7	10.0 10.5	Not found	
21353+2646	MLB 717	1931 1931	1	140 140	3.3 3.3	10.0 13.0	21 35 13.74 +26 45 57.5	%
21365+6449	MLB 224	1921 1921	1	112 112	5.2 5.2	10.0 12.0	21 36 22.95 +64 50 51.6	%
21419+4058	MLB 30	1917 1917	1	229 229	7.7 7.7	10.0 11.7	21 41 35.59 +40 56 15.1	%
21422+3008	MLB 575BC	1928 1984	2	96 114	2.5 2.3	11.3 12.5	21 42 11.95 +30 08 50.3	†
21458+2945	MLB 902	1933 2000	3	315 230	5.2 6.4	10.0 10.1	21 45 27.19 +29 48 27.9	%
21509+3918	MLB 788	1932 1976	2	54 52	4.2 4.7	10.0 10.1	21 50 55.55 +39 18 20.4	%
21564+3001	MLB 721AB	1931 1997	4	17 14	1.7 1.7	9.5 9.5		
21564+3001	MLB 721AC	1931 1931	1	206 206	5.3 5.3	9.5 12.0	21 56 21.85 +30 01 54.0	%

WDS 2000	Name	Epochs	N	PAs	Seps	Mags	This paper	Note
21593+2800	MLB 578	1928 1928	1	162 162	2.8 2.8	9.4 13.0	21 59 18.45 +27 59 43.6	%
22003+2922	MLB 497	1926 1926	1	186 186	7.4 7.4	10.5 11.6	22 00 22.81 +29 19 22.6	†
22045+2758	MLB 622	1929 1929	1	275 275	3.9 3.9	11.5 13.0	22 04 32.81 +27 59 24.4	%
22048+6735	MLB 369	1924 1924	1	109 109	5.7 5.7	11.0 13.0	22 04 55.71 +67 32 52.3	%
22075+3841	MLB 792	1932 1944	2	213 210	4.1 2.0	11.0 12.5	Not found	
22084+3919	MLB 793	1932 1932	1	210 210	5.4 5.4	9.8 10.3	Not found	
22111+4032	MLB 963	1934 1934	1	11 11	5.3 5.3	10.5 11.0	22 11 07.67 +40 31 43.0	%
22190+3912	MLB 994	1935 1935	1	255 255	3.3 3.3	11.1 13.1	Not found	
22201+6835	MLB 432	1925 1925	1	178 178	3.4 3.4	11.5 12.2	Not found	
22240+3855	MLB 904	1933 1933	1	105 105	5.3 5.3	10.0 11.0	22 23 53.79 +38 54 22.1	%
22371+3909	MLB 797	1932 1932	1	216 216	4.1 4.1	10.0 13.0	22 37 02.00 +39 09 24.7	%
22393+4000	MLB 906	1933 1933	1	224 224	4.4 4.4	10.0 10.5	Not found	
22423+2739	MLB 545	1927 1927	1	51 51	3.4 3.4	9.6 12.8	22 42 26.12 +27 39 33.8	%
22427+6835	MLB 316AB	1923 1997	4	121 122	3.5 3.0	10.9 11.0	22 42 39.23 +68 35 04.9	†
22427+6835	MLB 316AC	1923 1923	1	346 346	10.6 10.6	10.0 13.0		
22437+4015	MLB 995	1935 2004	2	298 301	4.3 4.8	10.0 10.1	22 43 42.85 +40 14 51.2	%
22469+3903	MLB 996	1935 1935	1	173 173	2.4 2.4	11.0 11.3	22 46 55.91 +39 02 48.3	%
22474+3917	MLB 799	1932 1932	1	301 301	4.1 4.1	10.2 11.5	Not found	
22505+3912	MLB 965	1934 1934	1	219 219	5.1 5.1	12.0 13.0	22 50 31.51 +39 12 20.6	%
22507+4005	MLB 966	1934 1934	1	117 117	6.4 6.4	10.0 11.0	22 50 41.63 +40 05 09.9	%

Notes

Note 1 B & R magnitude data not available from 2MASS catalogue.
Note x PA and separation significantly different since last measure in 1932.
∗ = denotes possible identification with Milburn pair. This means the pair is located close to WDS co-ordinates and generally has a PA and separation comparable with the Milburn data. Magnitudes are different but this may be due to Milburn estimates being visual.
† = denotes reasonable or good match with WDS data.
% = denotes possible match with WDS entry.
MLB 1: Is the second value of 325° correct for the PA? The PA in the image is approximately 221° .
MLB 259: Note: The PA is more like 241° than 116°

References

1.) Jaworski R. Measurement of the positions of Milburn (MLB) pairs from sky surveys. Webb Society Double Star Section Circulars, **14**, 63–70.

Charts

In the following diagrams, the open cross represents the WDS 2000.0 position.

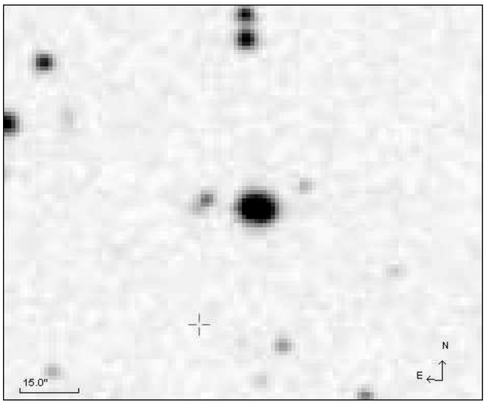


Figure 1
MLB 936; B=14.20; R = 10.60

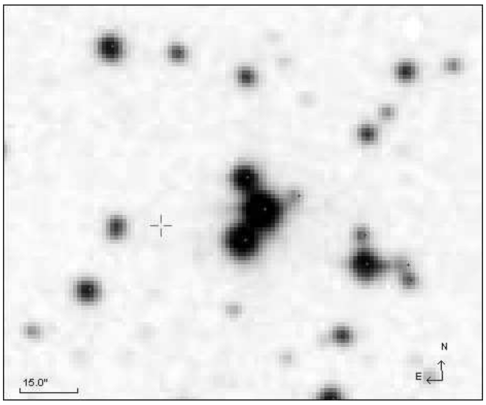


Figure 2
MLB 758ABC;

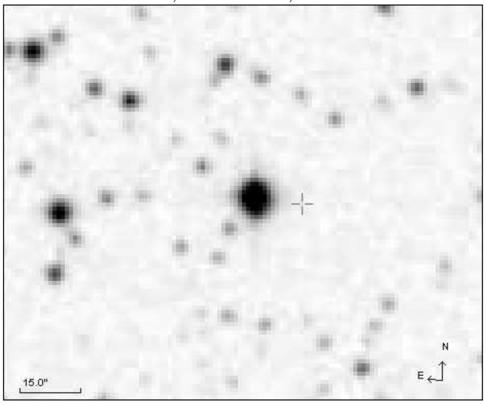


Figure 3
MLB 940 B = 12.35; R = 12.08

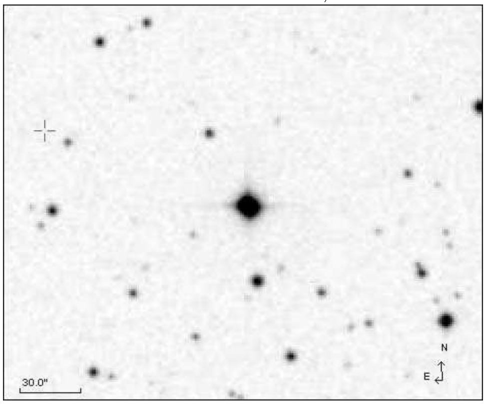


Figure 4
MLB 217 B = 12.17; R = 11.31

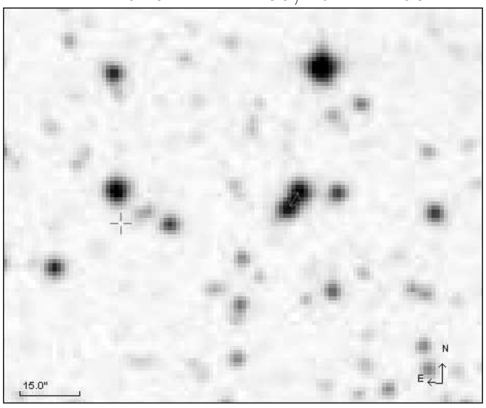


Figure 5
MLB 942 B = 13.20; R = 12.50

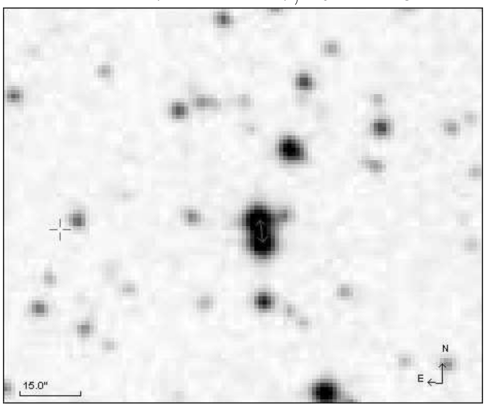


Figure 6
MLB 875 B = 12.60; R = 10.90

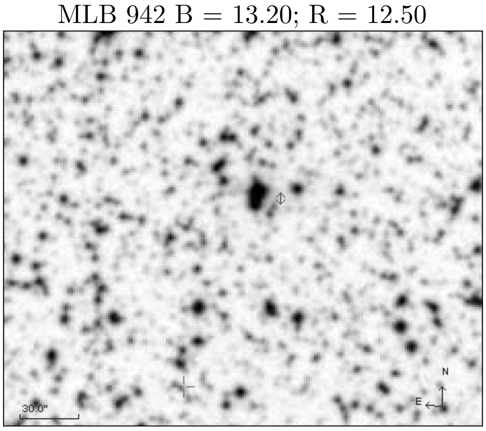


Figure 7
MLB 527 R=10.59; note 6

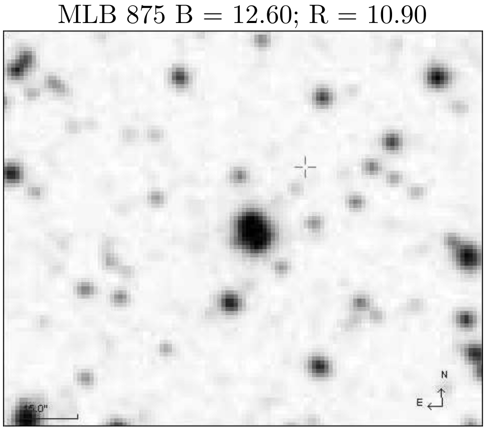


Figure 8
MLB 979 B= 12.60; R = 11.80

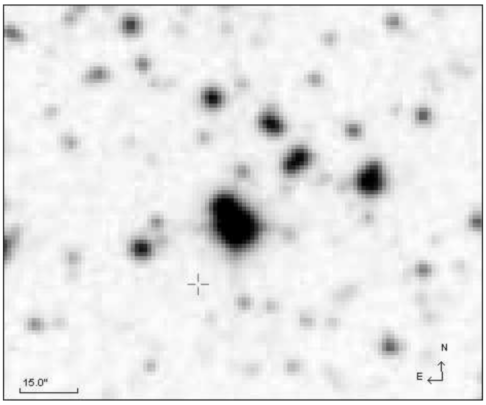


Figure 9
MLB 980 B = 12.25; R = 11.69

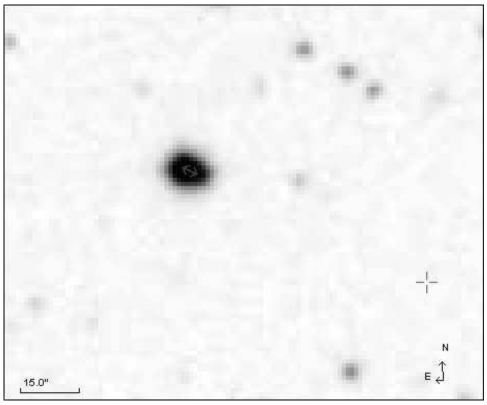


Figure 10
MLB 358 B = 12.90; R = 12.70

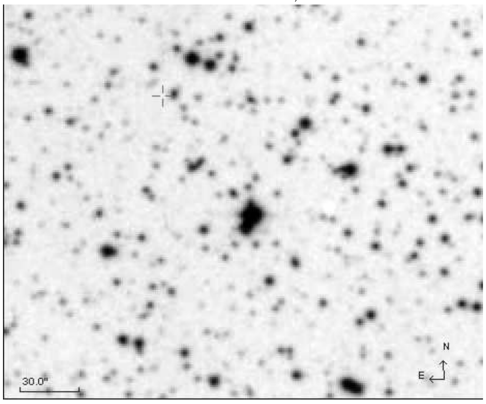


Figure 11
MLB 944 B = 10.43; R = 10.99

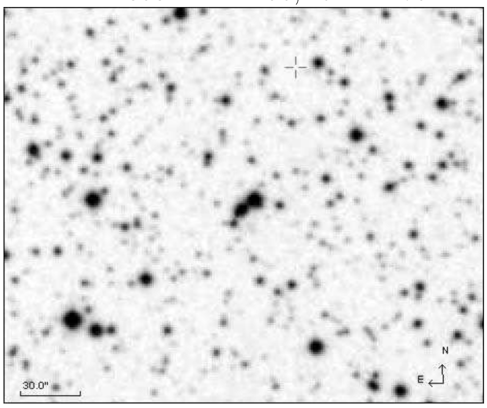


Figure 12
MLB 767 B= 12.86; note 6

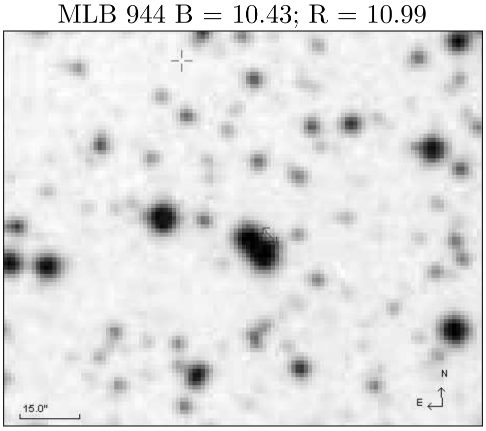


Figure 13
MLB 946 B = 13.00; R = 12.40

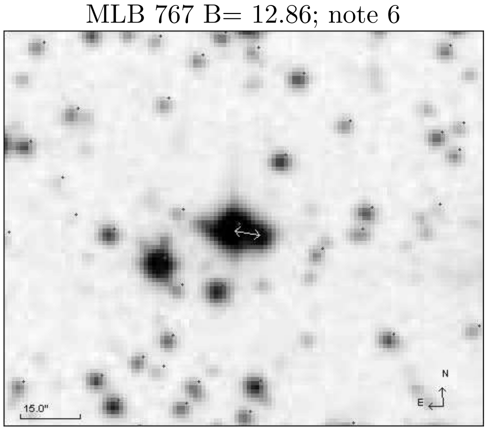


Figure 14
MLB 947 B = 12.40; R = 11.40

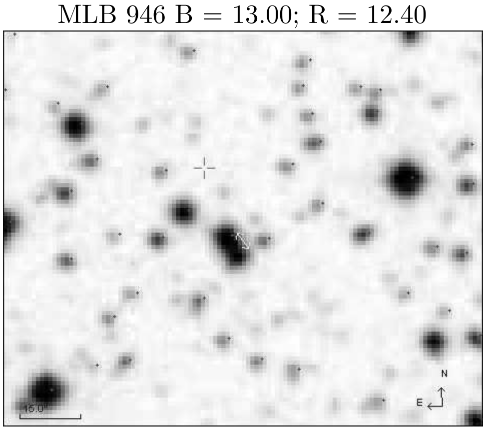


Figure 15
MLB 877 B = 14.50; R = 12.40

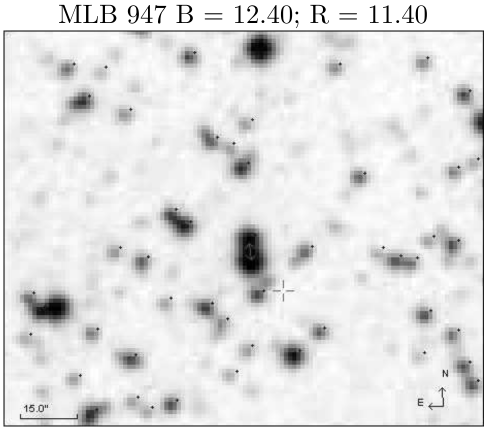


Figure 16
MLB 948 B = 12.90; R = 12.50

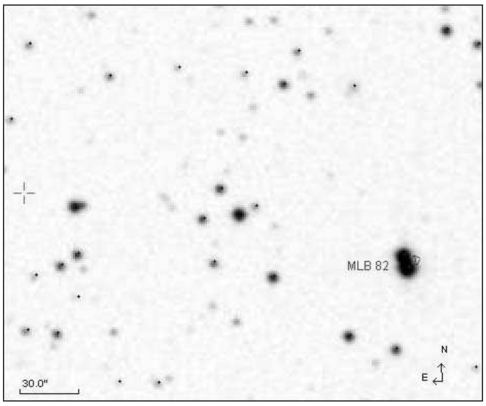


Figure 17
MLB 82 B = 12.80; R = 11.20

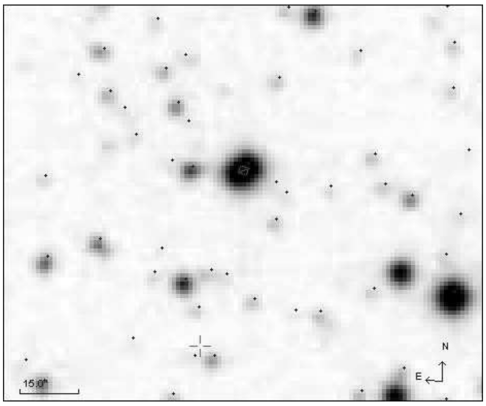


Figure 18
MLB 704 B= 13.30; R = 12.50

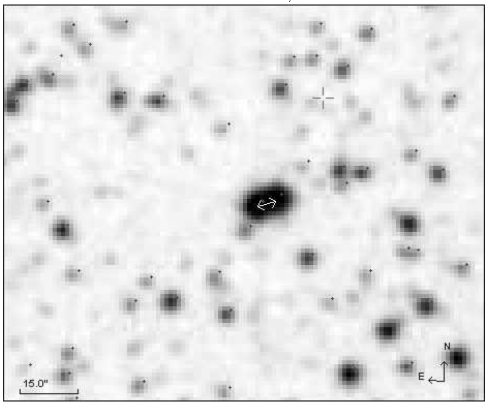


Figure 19
MLB 768 B=12.90; R=11.60

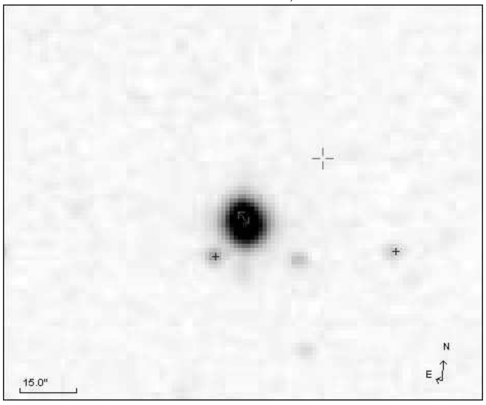


Figure 20
MLB 418 B = 12.30, R = 11.10

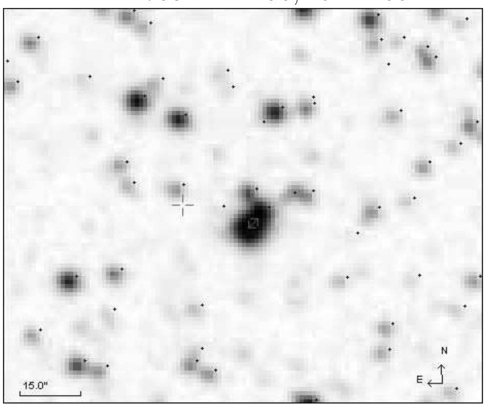


Figure 21
MLB 951; B=12.90, R=11.00

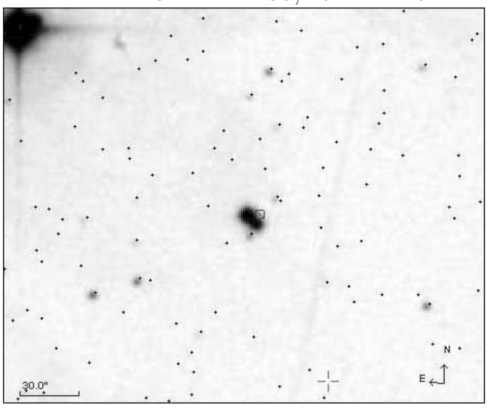


Figure 22
MLB 22 B = 12.46; R = 13.77

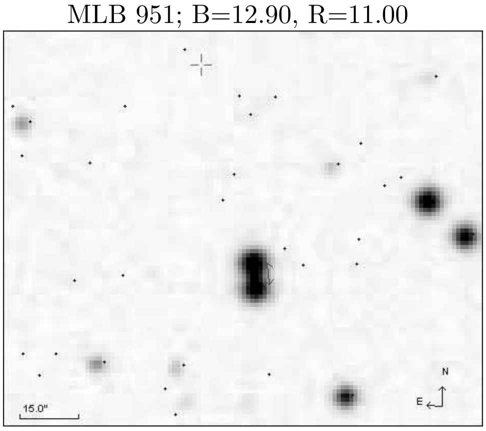


Figure 23
MLB 777 B = 13.10; R = 12.20

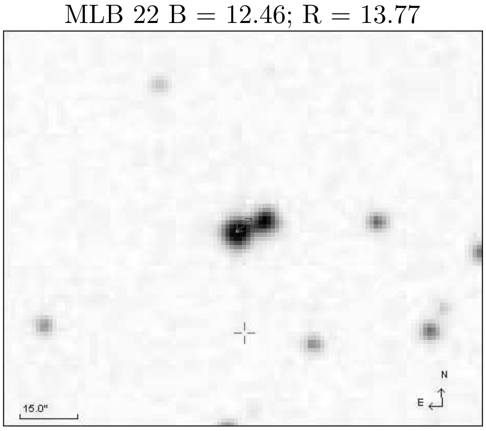
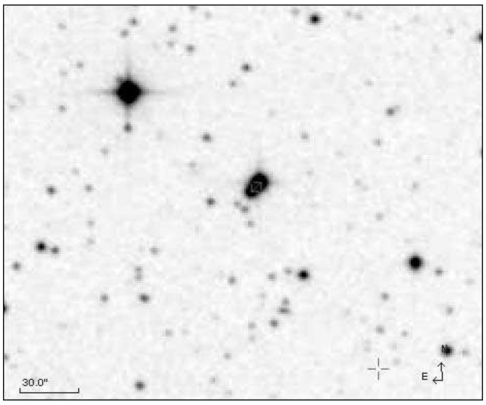


Figure 24
MLB 778 B= 13.10; R = 12.20



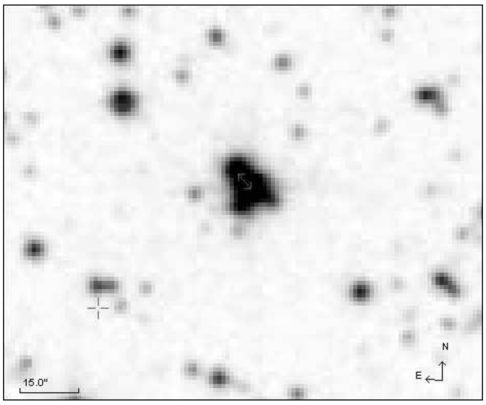
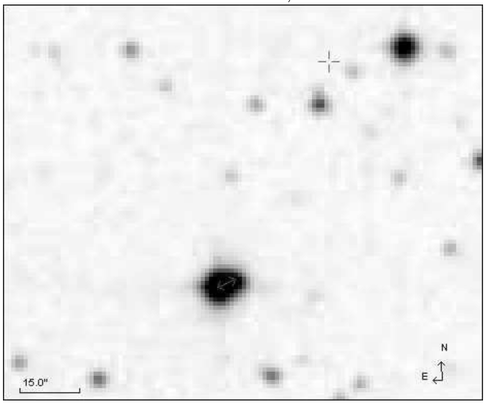


Figure 25
MLB 85 B = 12.25; R = 11.56

Figure 26
MLB 711 B = 11.47; R = 11.42



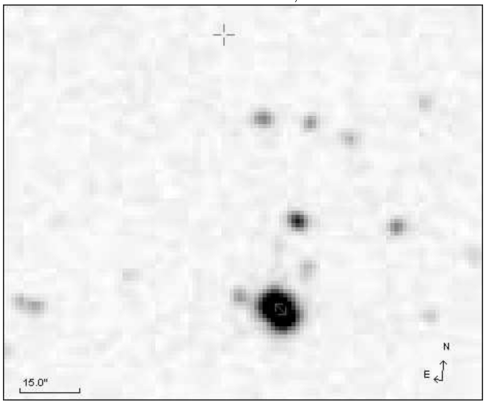
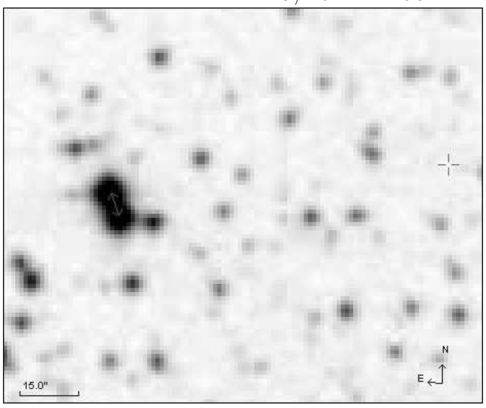


Figure 27
MLB 141 B = 12.43; R = 11.60

Figure 28
MLB 267 B = 12.90; R = 12.20



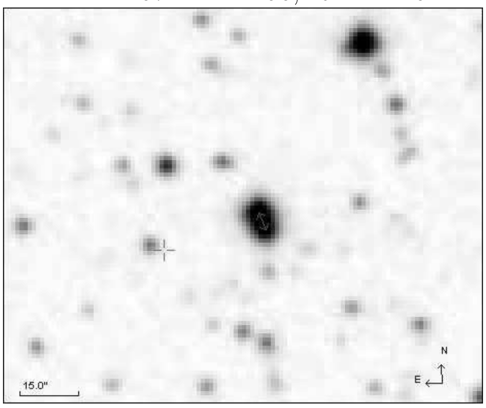
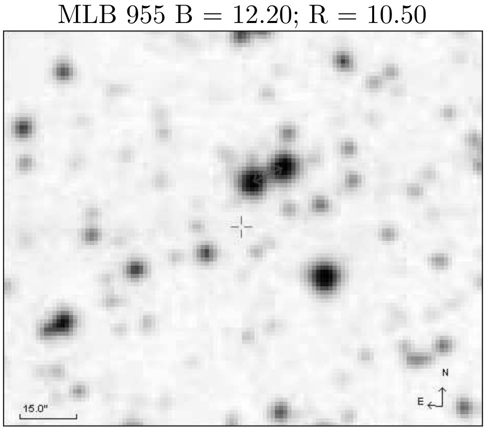


Figure 29
MLB 955 B = 12.20; R = 10.50

Figure 30
MLB 714 B= 13.00; R = 12.20



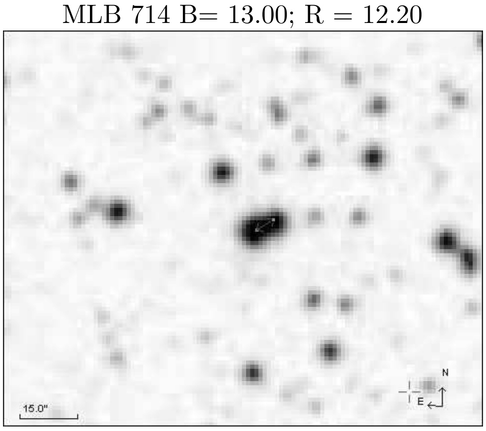


Figure 31
MLB 781 B = 12.72; note 6

Figure 32
MLB 783 B = 12.62; R = 12.34

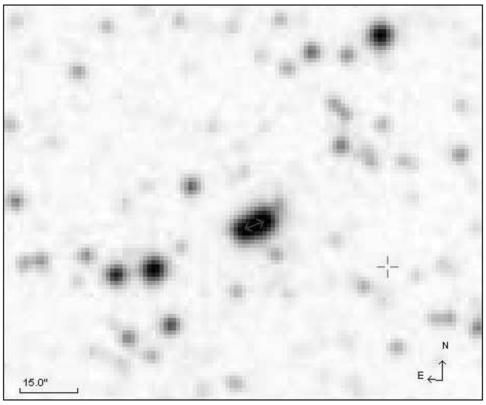


Figure 33
MLB 956 B = 12.50; R = 11.50

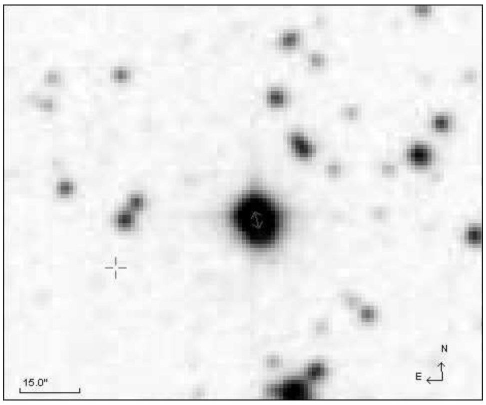


Figure 34
MLB 615 B = 13.10; R = 11.79

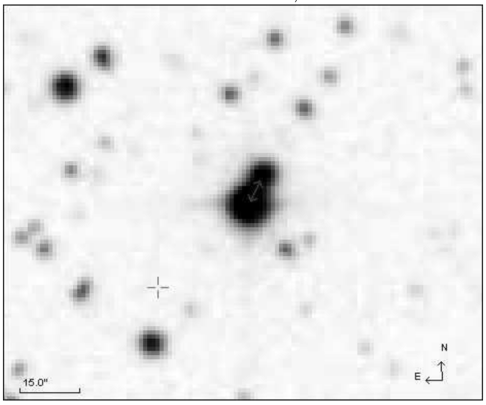


Figure 35
MLB 617 B = 13.52; R = 11.60

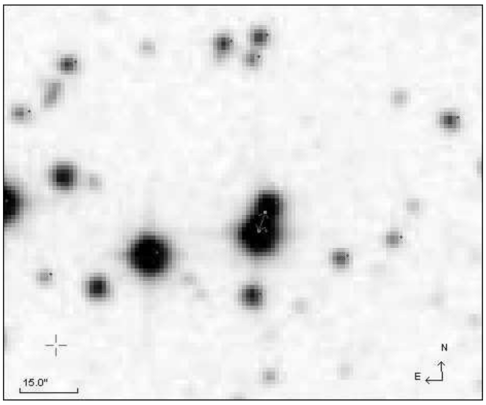


Figure 36
MLB 618 B= 13.10; R = 11.40

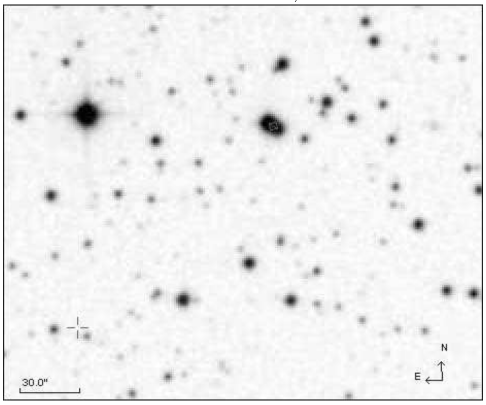


Figure 37
MLB 536 B = 12.90; R = 12.10

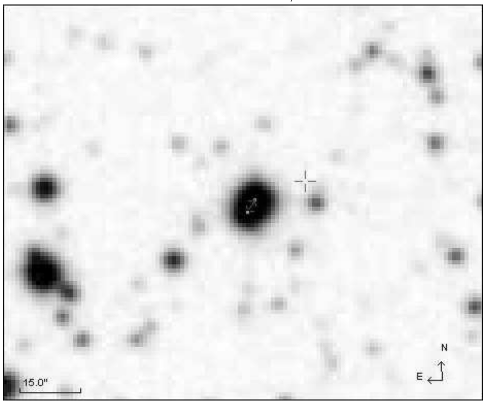


Figure 38
MLB 893 B = 12.70; R = 11.60

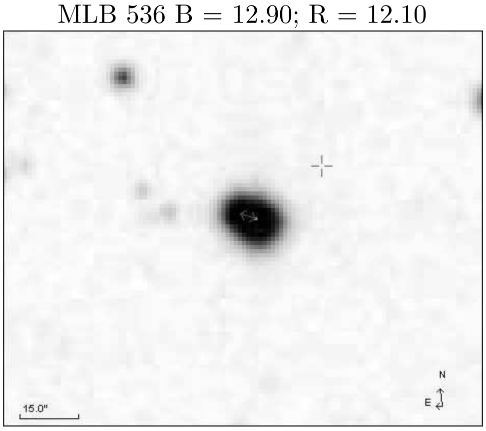


Figure 39
MLB 364 B = 12.29; R = 11.71

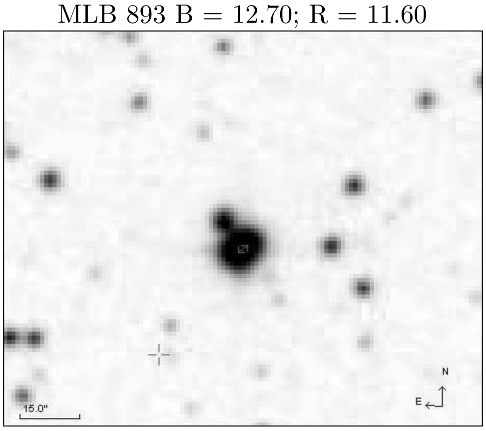


Figure 40
MLB 538 B = 12.55; R = 12.03

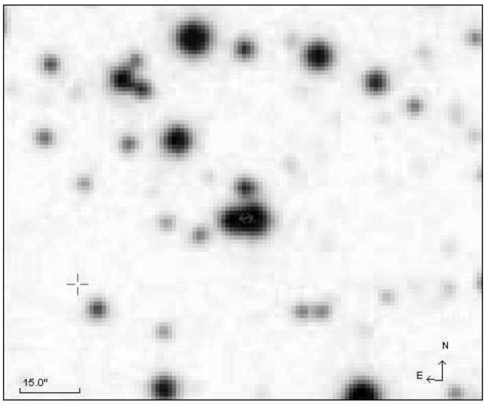


Figure 41
MLB 984 B = 13.50; R = 12.30

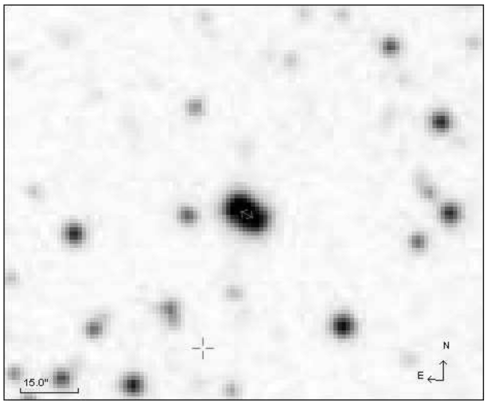


Figure 42
MLB 986 B = 13.50; R = 12.40

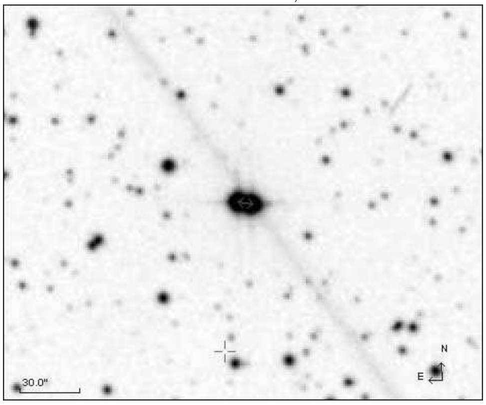


Figure 43
MLB 987 B= 12.20; R = 10.00

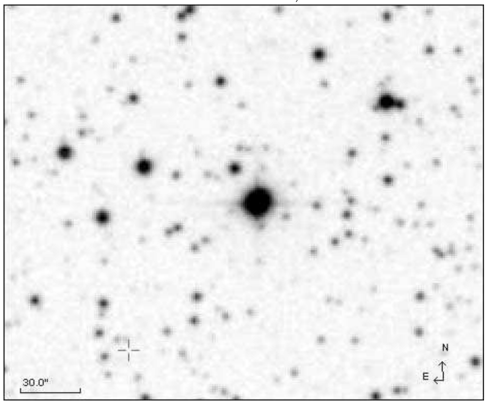


Figure 44
MLB 142 B = 10.72; R = 10.31

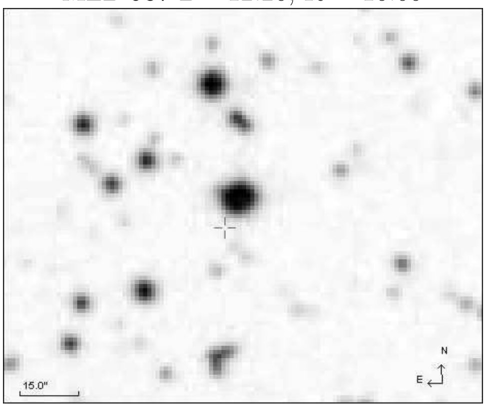


Figure 45
MLB 988 B = 13.50; R = 12.50

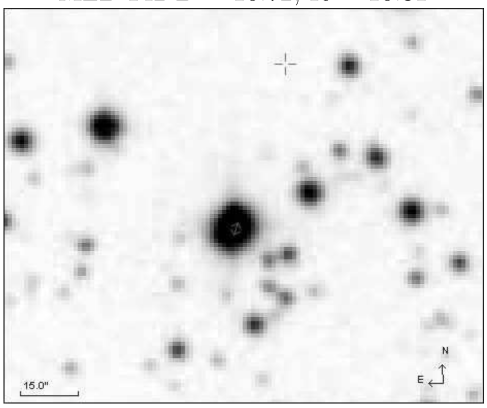


Figure 46
MLB 989 B = 12.24; R = 11.83

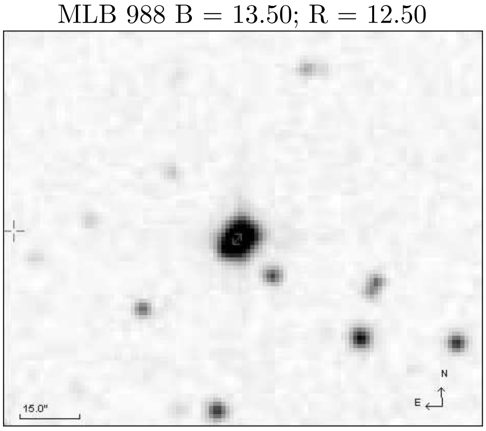


Figure 47
MLB 717 B = 12.62; R = 12.24

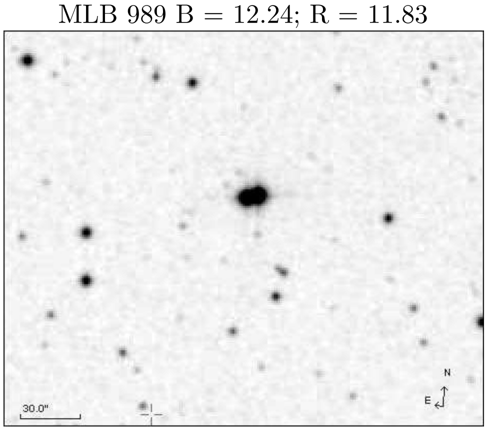


Figure 48
MLB 224 B = 12.38; R = 11.64

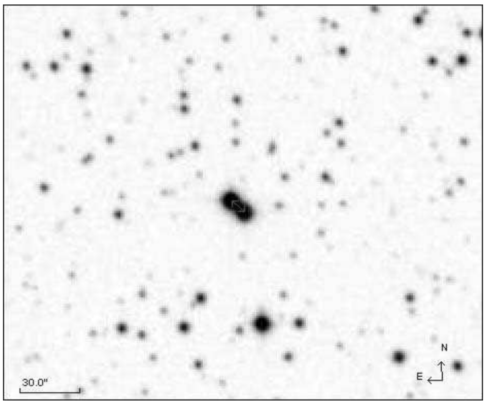


Figure 49
MLB 30 B = 11.90; R = 10.50

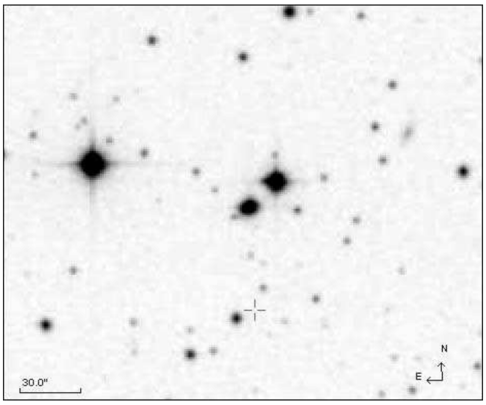


Figure 50
MLB 575BC B= 13.10; R = 11.50

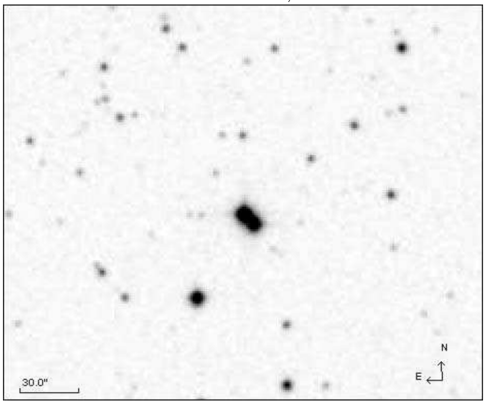


Figure 51
MLB 902 B = 12.00; R = 10.50

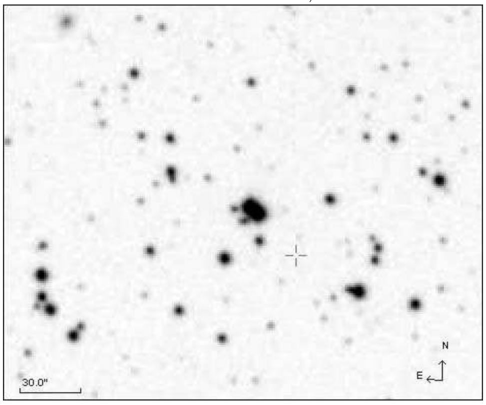


Figure 52
MLB 788 B = 12.00; R = 11.10

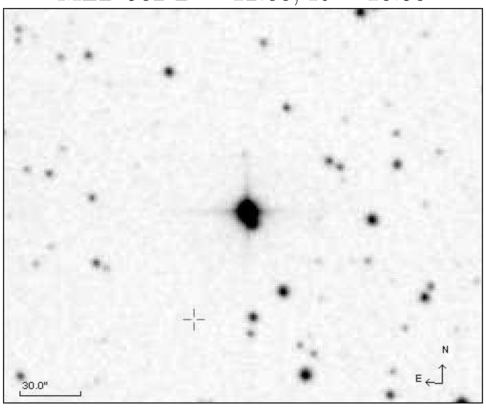


Figure 53
MLB 721 B = 11.94; R = 11.28

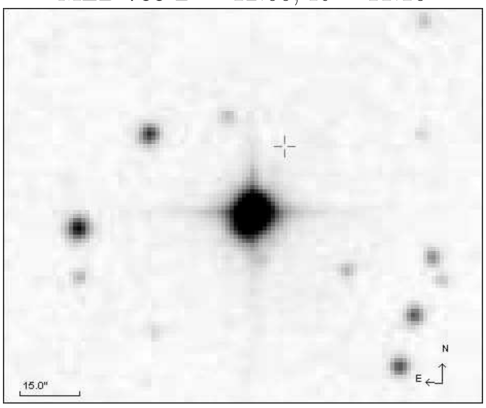


Figure 54
MLB 578 B = 11.67; R = 10.98

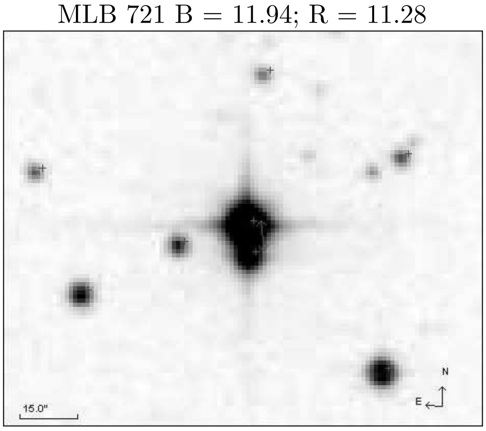


Figure 55
MLB 497 B = 11.76; R = 10.77

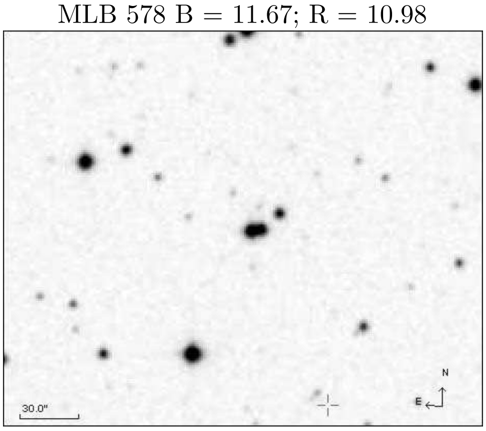


Figure 56
MLB 622 B= 13.10; R = 12.60

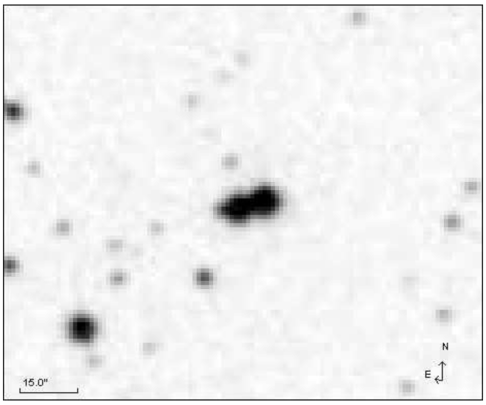


Figure 57
MLB 369 B = 12.70; R = 11.30

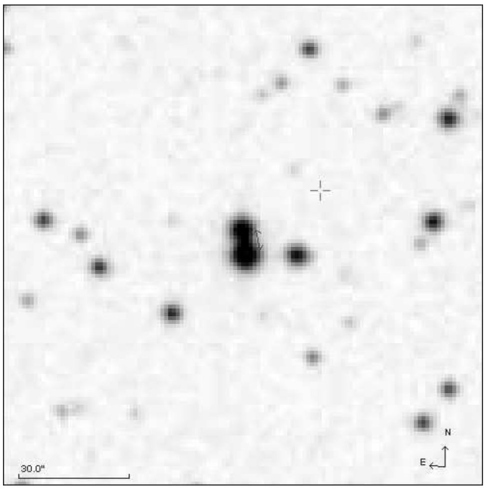


Figure 58
MLB 963 B = 12.90; R = 12.10

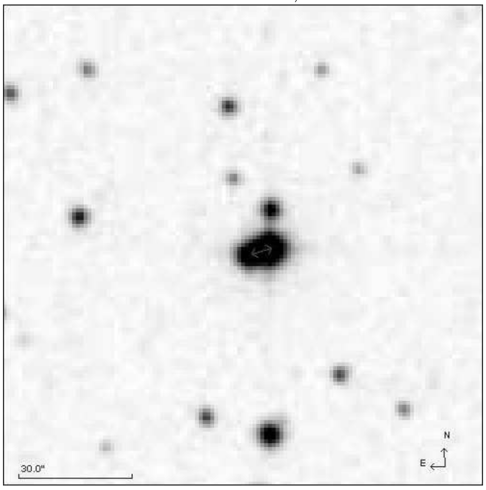


Figure 59
MLB 904 B = 12.10; R = 11.30

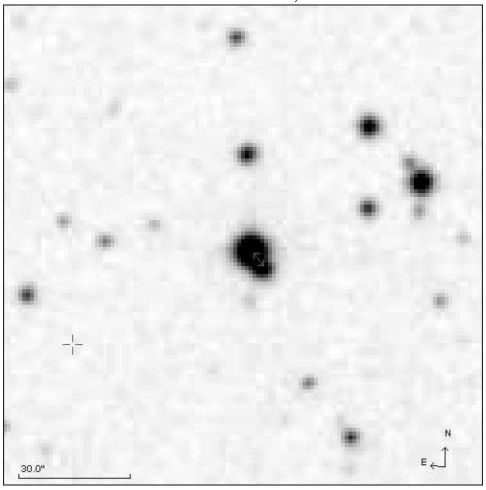


Figure 60
MLB 797 B = 13.13; R = 12.16

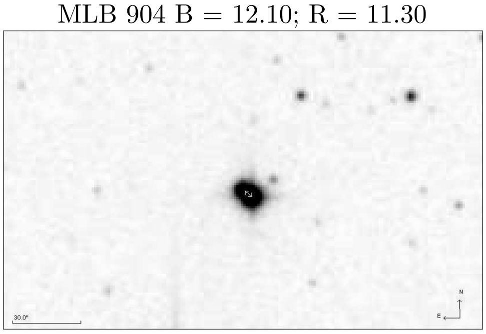


Figure 61
MLB 545 B = 11.71; R = 11.28

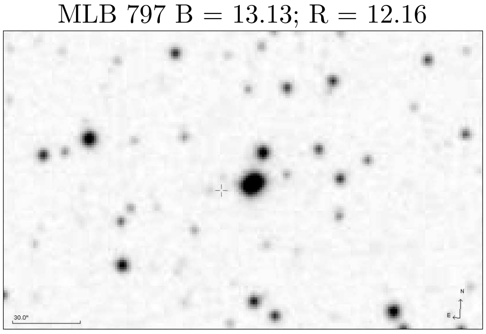


Figure 62
MLB 316 A = 12.80; R = 11.60

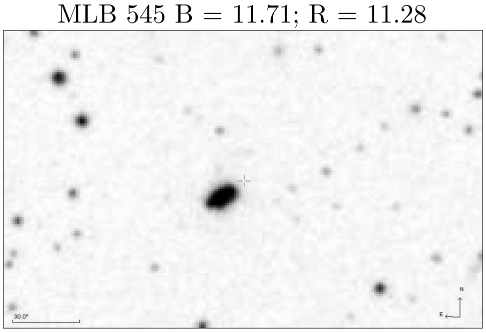


Figure 63
MLB 995 B= 13.00; R = 11.10

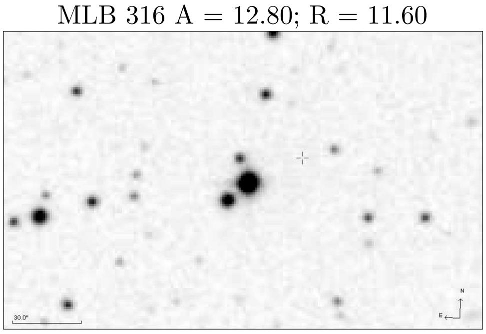


Figure 64
MLB 996 B = 13.20; R = 11.70

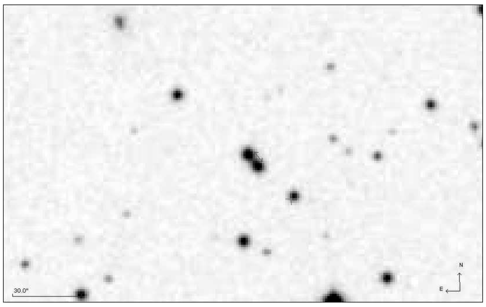


Figure 65
MLB 965 B = 13.70; R = 13.40

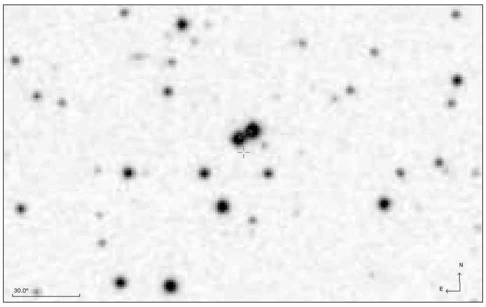


Figure 66
MLB 966 B = 12.80; R = 12.60

SOME MEASURES OF DOUBLE STARS USING THE CHRONOMETRIC METHOD, AN EYEPIECE MICROMETER AND THE ALADIN DATABASE

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Introduction

The double stars measured have been drawn from the s33 observing projects and the neglected list of the WDS. The methods used for the measurements are the chronometric, illuminated eyepiece micrometer and the Aladin Database for pairs too faint to be measured.

Method

An explanation of the chronometric measurement method is set out in DSSC 14[1]. Measurements using the illuminated reticle eyepiece follow the method set out by Tom Teague in the book 'Observing and Measuring Visual Double Stars'[2]. The telescope is an Orion Optics 8-inch f6 Newtonian. The eyepiece is a Celestron MicroGuide paired with a Meade 3x Barlow. This gives a scale constant of 5″.7 per division at a magnification of x288. Where a neglected pair has been observed at the correct co-ordinates but is too faint to be measured using these methods the Aladin[3] database is accessed and the pair measured using the POSSII N plate.

Results

Table 1. The measures for the non-neglected pairs

Pair	Comp	RA	DEC	PA	Sep	Epoch	N	Obs.	Method
STF 281		02359	+0536	79	7.5	2006.957	3	CSR	Microguide
HJ 2452		08316	+1806	63	69	2006.171	3	CSR	Chronometric
STF1334	A-Bb	09188	+3648	225	2.7	2006.256	3	CSR	Chronometric
STF1955	AB	15339	+2643	239	7.9	2006.552	3	CSR	Microguide
STF2003		16037	+1126	171	14.2	2006.552	3	CSR	Microguide
STF2010	AB	16081	+1703	14	28	2006.552	3	CSR	Microguide
STF2096	AB	16472	+0204	88	23.4	2006.606	3	CSR	Microguide
STF2098	AB	16457	+3000	147	14.3	2006.606	3	CSR	Microguide
STF2095		16451	+2821	161	5.7	2006.606	3	CSR	Microguide

Table 2. The measures for the neglected & non-observed pairs

Pair	Comp	RA	DEC	PA	Sep	Epoch	N	Obs.	Method
HL 30	AB	03493	+2424	14.8	66.8	2006.957	3	CSR	Microguide

Is HL 30 AB a duplicate of STU 2BC?

HL 30 AB is a neglected pair at co-ordinates 03h49.3m +24° 24′ . There is only one observation of this pair in the WDS from 1886. This pair is close to the bright star eta Tauri in the Pleiades. On investigating this pair I observed a pair close too these co-ordinates that were a very close fit to the WDS data (Table 2). Checking my results against the WDS I found a second pair that also were a good fit to the data. The pairs in question are HL 30 AB & STU 2 BC. The primary component of this pair is the secondary of the pair STTA 40. Sweeping the area using a 25mm Orthoscopic eyepiece to see if there was another double that could be a good fit to the WDS data and covering an area in excess of 1 degree I found there are no similar pairs. There is an associated pair HL 30 AC and this shares very similar structure to STU 2BD.

Table 3. Catalogue data for HL 30 and STU 2

Pair	Position	Magnitudes	Separation	PA	Measures	Year
HL 30 AB	03h 49.3m +24° 24′	7.53, 10	66.2	16	1	1886
STU 2 BC	03h 49.4m +24° 23′ ?	7.53,10.7	66.5	13	1	1986
HL 30 AC	03h 49.3m +24° 24′	7.53,10	81.1	242	4	2000
STU 2 BD	03h 49.4m +24° 23′	7.53,10.7	80.3	240	1	1986

Figure 1 shows the area around STTA 40 and clear shows that there is only one pair that matches the WDS data. I suspect that the pairs HL 30 AB & AC and STU 2 BC& BD are, in fact, identical.

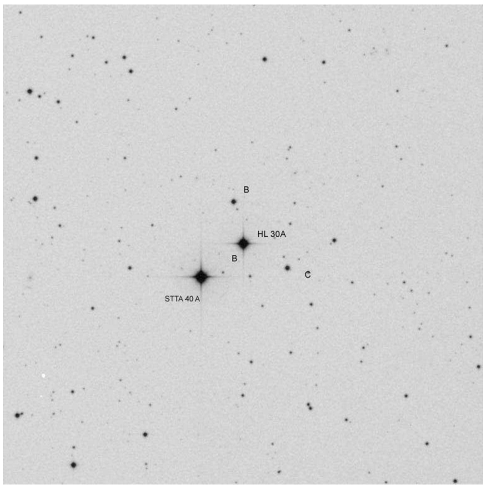

Figure 1:

SHR 1 - a single WDS entry but two possible candidate pairs?

SHR 1 is a neglected pair in Cepheus at 21h 27.5m +70° 28′ that has only been observed once, by the discoverer K. Schiller in 1910. The WDS co-ordinates place the pair approximately 10 arc minutes south west of beta Cephei. When sweeping this area with the 6mm Orthoscopic eyepiece (x200) I found two possible pairs. They were too faint to measure visually so using the Aladin database I have confirmed the existence of these pairs and the details are given in Table 3.

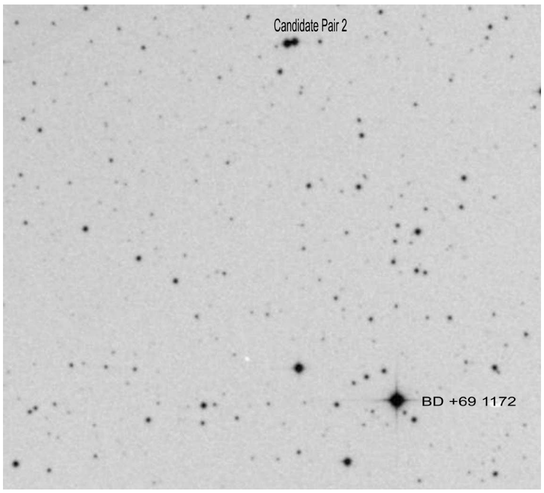

Figure 2: Showing the pair 6′ from BD +69° 1172

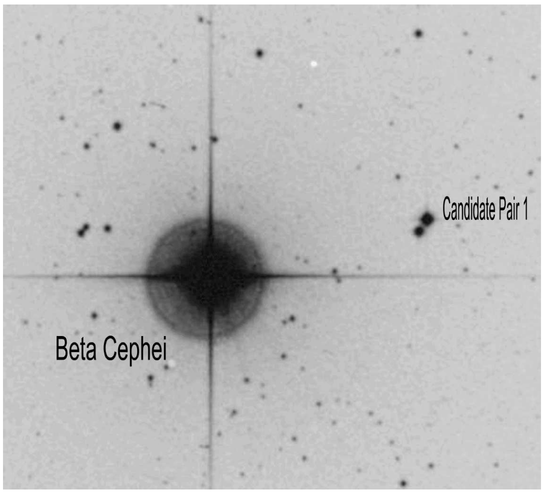

Figure 3: Showing the pair 3′ from β Cephei

The 2MASS RAJ2000 for the 1st pair are 21h 28m 05s.67 & +70° 34′13″.5
The 2MASS RAJ2000 for the 2nd pair are 21h 27m 25s.18 & +70° 28′07″.3

Pair 1 is located 3 arc minutes to the west of beta Cephei and about 7 arc minutes north east of the WDS co-ordinates. Whilst the co-ordinates are a poor fit to the WDS data, the position angle and separation agree well. Pair 2 is located 6 arc minutes north east of star BD +69° 1172 and is very close to the position given in the WDS but the PA and separation are not a good fit, and the stars in this pair are also fainter. A third pair (Pair 3), also found nearby, consists of the two stars TYC 4465 01049 1 & TYC 4465 02319 1. When the details of these two stars were compared from the TYCHO catalogue the proper motions appeared similar. Could this be a common proper motion pair? Other catalogues gave proper motions which were in broad agreement with Tycho - see Table 5 for the details.

Table 4. Measures for pairs near beta Cephei

Pair	Position	Magnitudes	Separation	PA	n	Epoch	Obs
Pair 1	21h28m.1 +70° 34′	± 11	11.1	143.2	3	1995.741	CSR
Pair 2	21h27m.5 +70° 28′ ?	±11.5	7.5	279	3	1995.741	CSR
Pair 3	21h30m.9 +70° 20′		11.4	66	3	2006.902	CSR

SHR 1 was found by Schiller in 1910 whilst making micrometric measurements of Beta Cephei (Σ2806). The position that he recorded, when precessed from 1910 to 2000, gives the position quoted in the WDS. However when the positions of both Pair 1 and 2 are looked up in the 2MASS catalogue it appears that the second pair corresponds to the WDS position and that Schiller must have misidentified the pair when he came to calculate the position. It is therefore proposed that the WDS position for SHR 1 should read 21281+7034, and that Pairs 2 and 3 are not currently listed in the WDS.

Table 5. Catalogue proper motion data for Pair 3

	TYC 4465 1049 1				TYC 4465 2319 1		
	pm(RA)	pm(DEC)	$B-V$		pm(RA)	pm(DEC)	$B-V$
TYC	−8.6	−6.2	0.13	TYC	−7.4	−4.6	
USNO B	−10	−8		USNO B	−8	−6	
NOMAD	−8.5	−6.2	0.133	NOMAD	−7.2	−4.5	0.42
ASCC	−7.6	−5.71	0.199	ASCC	−7.14	−4.49	0.476
UCAC2	−8.5	−6.2		UCAC2	−7.2	−4.6	

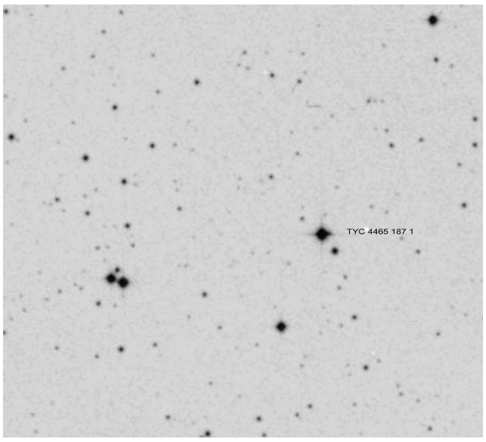

Figure 4: Field of view around TYC 4465-187-1

Acknowledgements

The author would like to thank Bob Argyle and Dr. Brian Mason for their assistance with SHR 1.

References

1. Webb Society Double Star Section Circulars, **14**, 2005
2. Observing and Measuring Visual Double Stars, Chp 12 Tom Teague (Ed. Bob Argyle), 2004
3. The Centre Du Donnees astronomiques de Strasbourg

CANDIDATE BINARY STAR SYSTEMS IN THE SLOAN DIGITAL SKY SURVEY RELEASE FIVE

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Abstract

Analysis of data from a small sample from the Sloan Digital Sky Survey Data Release Five has identified three candidate binary systems using the Color-Induced Displacement technique.

Introduction

Any image of an unresolved double star, regardless of the filter used, will have its photocentre somewhere between the two components and the position of the photocentre will depend both the colour of the stars and on the filter used. Consider the example of an unresolved double star with one red and one blue/white component. Using a red filter will generate a photocentre much closer to the position of the red star than to the position of the blue/white star while the opposite would be the case if a blue filter was used.

Pourbaix ([1,2]), whose work covered data releases one and three, described the features of the Sloan Digital Sky Survey (SDSS) data that allowed the successful identification of these Color-Induced Displacement (CID) binaries. In the SDSS the position of an object and its magnitude are measured in five bands. Even with a single star the quoted positions do not coincide exactly due to measurement errors and for double stars the *u* and *z* band readings will always be furthest apart because these two filters have the largest central wavelength difference.

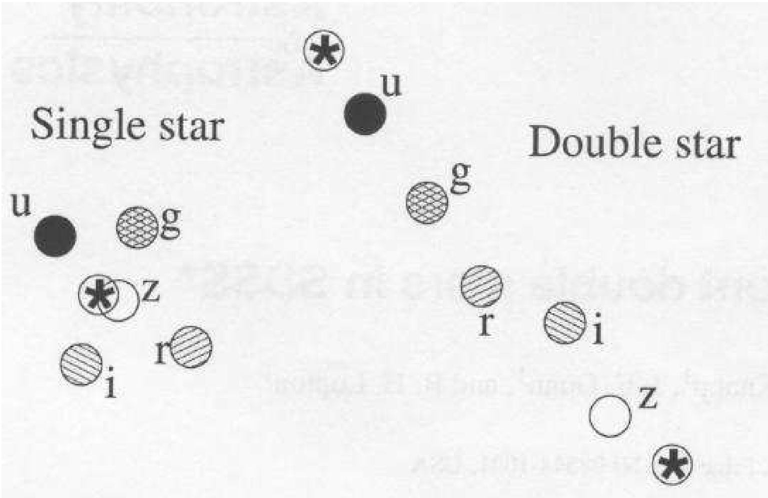

Figure 2: Example of photocentre positions in different SDSS bands

The positions are approximately aligned between the two stars and they are in wavelength order. Errors in the measurements will prevent perfect alignment between the two stars represented by the star symbols.

Data Analysis

In order to identify CID binaries two key parameters need to be measured. These are angle between *u* and *z* measured from point *r* and the distance *u,z*.

Pourbaix suggested that in order to distinguish reliably between single and double stars the lower limit for the angle *u,r,z* should be taken as 1.5 radians (85.94 degrees) and the lower limit for the distance *u,z* should be 0.5 arc seconds.

In order to further enhance the reliability of the test three further conditions were imposed:-
* both *u* and *g* magnitudes < 21
* precision for *u* and $r < 0.1$
* magnitude precision for *g*, *i* and $z < 0.05$

One complicating feature of the SDSS data is the presence of asteroids. The observed change in the photocentre occurs because the asteroid moves in the time between the exposures taken with the different filters. The order that the exposures are taken is *r, i, z, u, g* - in other words *u* and *z* are the same side of *r* - so that the angle *u,r,z* will be close to zero. This means that the Pourbaix constraints listed above will be effective in obtaining a sample of potential binary systems rather than an asteroid and binary system mixture.

Asteroids are best detected by filtering the data based on the distance *r,g* and the angle *r,z,g*.

Table 1 - candidate binary systems

No.	RA	DEC	Angle (degrees)	Distance *u,z*
1	206.801083	23.751999	171.96	0.51
2	209.109516	23.097290	95.31	0.51
3	209.473936	23.146170	93.46	0.72

Table 2 -photometry

No.	*u-g* colour	*g-r* colour	2MASS *J-K*	Classification based on Pourbaix (Fig 4)
1	1.98	1.85	0.846	White and M dwarf?
2	2.53	1.51	0.831	White and M dwarf
3	2.33	1.62	0.829	White and M dwarf

Discussion

Although adopting the approach suggested by Pourbaix does yield some previously unreported candidate binary systems from the fifth data release of SDSS the percentage yield is extremely low. Very few candidates stars have a separation *(u,z)* greater than the cut-off point of 0.5 arc seconds and of these most are clearly asteroids.

However data release five covers a large area of the sky not surveyed by Pourbaix in his work that used data release three - see figure 2.

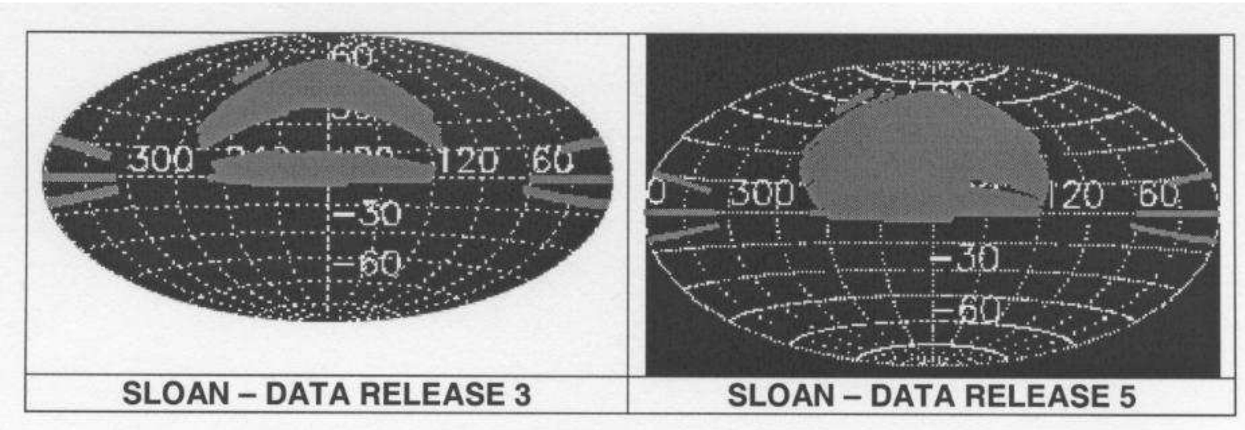

Figure 3: Figure 2 - Sky coverage by SDSS data releases

For this reason is it hoped to examine the entire data release five, rather than just a small sample, during 2007.

References

1. Pourbaix, D., Tokovinin, A. A., Batten, A. H., 2004, *et al.* Color-Induced Displacement double stars in SDSS, *Astronomy and Astrophysics*, **423**, 755-760
2. Pourbaix, D., 2005, Identifying CID binaries in SDSS and in Gaia later on, in *Astrometry in the Age of the Next Generation of Large Telescopes*, ASP Conference Series, **338**

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