

DOUBLE STAR MEASUREMENTS WITH AN ASTROMETRIC EYE-PIECE IN 2016

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Introduction

The following measurements were made with a Meade 12-mm astrometric illuminated reticle eyepiece attached to a recently purchased Altair Astro 115-mm refractor (focal length 805mm, f7). The optical train also employed a 2.5x Powermate to give a total magnification of 167.5x. Calibration was achieved over two evenings using the timing/transit method as outlined in Teague¹. Three separate stars were used and the results (reassuringly close) averaged to give a calibration of: $12''.49 \pm 0''.4$ per division on the measuring scale.

Method

Earlier attempts with a smaller scope (SW 80-mm APO) had indicated the necessity of taking multiple readings to achieve a credible result. Unless stated, each system has 10 separation and 10 position angle measurements ($N = 20$) from which a final result and associated uncertainty were calculated. As expected the later results were, overall, found to be closer to WDS values especially in P.A. Early P.A. values were made by turning the motor off and allowing the primary to drift and cross the outer protractor scale. The scope was moved manually in R.A. to allow further measurements to be made. However, even with a relatively small system this was not easy and the following method was adopted:

With the motor on, the two stars were positioned parallel to the measurement-axis with the primary positioned to pass through the centre-point. The system was then steered to the outer scale using the R.A. control on the handset. The value that the primary passed through was noted and the appropriate conversion to the correct P.A. value made afterwards.

This has the advantage that repeated measurements can be easily made and the scope can be easily slewed to the next system afterwards. The PA results were seen to immediately improve using this method. It, of course, relies on precise polar alignment of the mount so movement in declination is at an absolute minimum.

Due to the small magnification of the system the limiting useful minimum separation measurement is about $14''$. The accuracy of PA for small separations is also harder to achieve especially if the secondary is very faint. The faintest magnitude used for measurement was 10.3 due partly to local light pollution but also due to the obscuring red light used to illuminate the measuring eyepiece.

As most of these systems are comparatively wide the orbits are generally very long (30,000 years+) and very few have accurate orbital calculations. Residuals (from the online version of 6th USNO Catalogue of Orbits of Visual Binary Stars) have been given for the few systems calculated.

Residuals from the Fourth Catalogue of Interferometric Measurements have provided a more extensive set of residuals.

References

- (1) Teague, E. T. H. (2012) in Argyle, R. W. (ed.), *Observing and Measuring Visual Double Stars*, Springer
- (2) *The Cambridge Double Star Atlas*, (Mullany J. Tirion W. pub. Cambridge)
- (3) *Washington Double Star Catalogue* (Mason, B.D., Wycoff, G.L. & Hartkopf, W.I.):

(4) <http://ad.usno.navy.mil/proj/WDS>

(5) Sixth Catalogue of Orbits of Visual Binary Stars (Hartkopf, W.I., Mason, B.D. & Worley, C.E.):

<http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/orb6/sixth-catalog-of-orbits-o>

(6) Fourth Catalogue of Interferometric Measurements of Binary Stars:

<http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/int4>

Table 1: Measures of Double Stars

Pair	Comp	RA	Dec	V_a	V_b	PA ($^\circ$)	\pm ($^\circ$)	Sep ($''$)	\pm ($''$)	Epoch (2016+)	N	Obs
STF 30	AB	00272	+4959	6.96	8.92	314.0	0.2	12.8	0.1	0.903	20	WST
STF 60	AB	00491	+5749	3.52	7.36	324.2	0.1	12.9	0.1	0.903	20	WST
STF 948	AC	06462	+5927	5.44	7.05	306.7	0.2	9.3	0.2	0.350	20	WST
STF1110	AC	07346	+3153	1.93	9.83	162.2	0.4	69.8	0.4	0.308	20	WST
STF1268	AB	08467	+0846	4.13	5.99	307.9	0.3	31.3	0.3	0.294	20	WST
STF1315		09128	+6141	7.33	7.65	27.3	0.3	24.6	0.2	0.350	20	WST
STF1321	AB	09144	+5241	7.79v	7.88v	97.4	0.2	17.2	0.3	0.369	20	WST
STF1415	AB	10178	+7104	6.65	7.27	167.7	0.1	16.9	0.2	0.635	20	WST
LDS2863	AB	10306	+5559	4.88	8.86	302.9	0.1	122.8	0.4	0.635	20	WST
STF1495		10598	+5854	7.25	8.84	36.0	0.1	34.2	0.2	0.643	20	WST
ENG 45	AB	11118	+4250	7.24	8.30	247.3	0.1	135.0	0.5	0.643	20	WST
STF1520	AB	11161	+5246	6.54	7.81	345.8	0.1	11.9	0.2	0.643	20	WST
STF1579	AB-D	11551	+4629	6.68	6.97	113.7	0.2	62.6	0.2	0.297	20	WST
STF1657	AB	12351	+1823	5.11	6.33	270.0	0.1	21.6	0.3	0.294	20	WST
STF1687	AC	12533	+2115	5.15	9.76	127.1	0.5	28.5	0.3	0.369	20	WST
STF1692	AB	12560	+3819	2.85	5.52	228.5	0.2	20.0	0.3	0.291	20	WST
STF1744	AB	13239	+5456	2.23	3.88	152.4	0.2	14.4	0.2	0.294	20	WST
STF1821	AB	14135	+5147	4.53	6.62	237.5	0.1	13.1	0.2	0.294	20	WST
STFA 28	AB	15245	+3723	4.33	7.09	171.0	0.3	109.0	0.4	0.294	20	WST
STF2010	AB	16081	+1703	5.10	6.21	13.0	0.4	26.5	0.3	0.342	20	WST
STF2078	AC	16362	+5255	5.38	5.50	193.3	0.2	89.3	0.4	0.311	20	WST
STFA 35		17322	+5511	4.87	4.90	310.0	0.1	62.5	0.1	0.294	20	WST
STF2241	AB	17419	+7209	4.60	5.59	15.1	0.3	30.7	0.3	0.342	20	WST
STF2308	AB	18002	+8000	5.70	6.00	231.4	0.2	20.0	0.3	0.326	20	WST
STFA 38	AD	18448	+3736	4.34	5.62	149.9	0.2	44.2	0.1	0.623	20	WST
STF2426	AB	19000	+1253	7.45	8.96	260.6	0.2	16.6	0.2	0.627	20	WST
SHJ 286		19050	-0402	5.52	6.98	208.9	0.3	39.1	0.3	0.553	19	WST
STTA178		19153	+1505	5.69	7.68	266.8	0.3	89.8	0.4	0.624	18	WST
STT 588	AB	19250	+1157	5.24	8.65	282.1	0.2	104.0	0.5	0.631	20	WST
STFA 43	AB	19307	+2758	3.19	4.68	53.8	0.2	34.6	0.3	0.621	20	WST
STFA 46	AB	19418	+5032	6.00	6.23	132.5	0.3	40.0	0.1	0.621	20	WST
STF2578	AB	19457	+3605	6.37	7.04	122.8	0.1	14.6	0.2	0.646	20	WST
WEB 9	AB	20007	+3635	6.69	8.97	202.0	0.1	71.6	0.3	0.646	20	WST
STFA 50	AC	20136	+4644	3.93	6.97	172.7	0.1	108.6	0.5	0.616	20	WST
STFA 50	AD	20136	+4644	3.93	4.83	322.3	0.1	336.7	1.1	0.616	20	WST
ENG 72	AB	20145	+3648	4.96	6.71	154.9	0.2	215.3	0.7	0.646	20	WST
HO 588	AB	20169	+3130	6.91	8.89	296.8	0.3	50.8	0.2	0.646	20	WST
STTA205		20197	+4108	7.19	8.91	320.4	0.3	46.2	0.3	0.646	20	WST
STF2758	AB	21069	+3845	5.20	6.05	154.9	0.2	33.3	0.3	0.616	20	WST
STF2806	AB	21287	+7034	3.17	8.63	251.4	0.2	13.5	0.2	0.662	20	WST

STFA 57	AB	21344	†6644	7.07	7.18	25.2	0.2	183.1	0.7	0.721	20	WST
STF2816	AC	21390	†5729	5.73	7.48	117.1	0.2	11.9	0.1	0.794	20	WST
STF2816	AD	21390	†5729	5.73	7.53	338.7	0.2	20.7	0.2	0.794	20	WST
STF2840	AB	21520	†5548	5.64	6.42	196.4	0.2	17.9	0.3	0.721	20	WST
S 800	AB	21538	†6237	7.07	7.91	145.1	0.1	62.5	0.1	0.721	20	WST
STF2873	AB	21582	†8252	7.00	7.47	66.1	0.2	13.4	0.2	0.739	20	WST
STT 461	AD	22039	†5949	6.66	7.84	72.0	0.1	184.0	0.6	0.794	20	WST
STT 461	AE	22039	†5949	6.66	6.96	36.9	0.1	237.1	0.8	0.794	20	WST
STT 461	AC	22039	+5949	6.66	10.03	39.7	0.1	89.2	0.4	0.794	20	WST
STF2872	A-BC	22086	+5917	7.14	7.98	314.6	0.1	22.0	0.2	0.739	20	WST
STF2883		22106	+7008	5.56	8.56	252.8	0.3	14.2	0.2	0.750	20	WST
STF2893		22129	+7318	6.19	7.91	347.0	0.2	28.9	0.2	0.750	20	WST
STF2894	AB	22189	+3746	6.21	8.85	193.9	0.1	16.1	0.2	0.903	20	WST
STFA 58	AC	22292	+5825	4.21	6.11	191.2	0.2	40.3	0.2	0.750	20	WST
HJ 1786	AB	22345	+4046	7.00	9.46	226.0	0.1	43.5	0.3	0.758	20	WST
STF2922	AB	22359	+3938	5.66	6.29	185.2	0.1	22.5	0.2	0.758	20	WST
A 1469	AD	22359	+3938	5.66	9.08	142.6	0.2	81.7	0.3	0.758	20	WST
A 1469	AE	22359	+3938	5.66	7.25	238.6	0.1	335.2	1.1	0.758	20	WST
S 813	AB	22393	+3903	4.84	10.3	47.2	0.2	62.6	0.2	0.834	20	WST
STT 480		22461	†5804	7.65	8.64	116.4	0.2	30.7	0.2	0.750	20	WST
STA 238	AB	22527	†6759	7.02	7.58	280.3	0.1	68.8	0.4	0.758	20	WST
STF2960	AC	22564	†4136	5.56	9.35	47.1	0.2	61.5	0.2	0.834	20	WST

Table 2: Residuals from known orbits

Pair	ADS	Residual(O-C)		Orbit	Period(yrs)	Date	Grade
		PA(°)	Sep(")				
STF 1110	6175	-4.1	-1.8	Kiyaeva	187200	2015	5
		-5.8	-0.1	Kiyaeva	134630	2015	5
		-4.9	†0.4	Kiyaeva	128170	2015	5
STF 1321	7251	-0.8	†0.3	Chang	975	1972	4
STF 1821	9173	†2.2	-0.7	Kiyaeva	61010	2006	5
		†2.7	-1.1	Kiyaeva	66750	2006	5
STF 2241	10759	-1.7	†1.1	Kiselev	31000	2009	5
STF 2308	11061	0.0	†1.2	Kiselev	18000	1996	5
STFA 46	12815	-0.6	†0.2	Hauser, Marcy	135127	1999	4
STF 2758	14636	†2.9	†1.7	Polyakov	678	2006	4
STF 2873	15571	†0.3	-0.3	Polyakov	192400	2006	5

Table 3: Residuals from Fourth Catalogue of Interferometric Measurements

Pair	ADS	HIP (TYC)	Epoch (catalogue)	(O-C)	(O-C)
				PA(°)	Sep(")
STF 30 AB	361	2151	2003.809	†1.4	-1.0
STF 60	671	3821	2003.766	†5.5	†0.1
STF 948 AC	5400	32438	2008.885	-2.0	†0.6
STF 1110 AC	6175	36850	1991.25	-1.2	-1.2

STF 1268 AB	6988	43100	2003.283	↑0.2	↑1.1
STF 1315	7226	45206	1991.59	↑0.4	-0.2
STF 1415	7705	50433	2003.251	↑0.4	↑0.4
LDS 2863 AB		51459	1991.70	-0.1	0.0
STF 1495	8001	53750	1991.64	-0.6	↑0.1
ENG 45 AB		54692	1991.75	↑0.1	↑0.2
STF 1520 AB	8108	55044	2013.0556	↑3.1	-0.2
STF 1579 AB-D	8347	58112	1991.73	-0.1	-0.4
STF 1657 AB	8600	61418	2003.284	-0.1	+1.7
STF 1692 AB	8706	63125	2003.284	-0.1	+0.9
STF 1744 AB	8891	65378	2012.190	+1.5	+0.8
STF 1821 AB	9173	69483	2008.278	+2.0	-0.5
STFA 28 AB	9626	75411	1991.62	0.0	+0.1
STF 2010	9933	79043	2003.418	0.0	-0.9
STF 2078 AC	10129	81292	1991.68	-0.9	-0.1
STFA 35	10628	85829	1999.40	-1.2	+0.3
STF 2241 AB	10759	86614	1991.70	-0.4	+0.5
STF 2308 AB	11061	88136	2012.7725	+1.4	+0.5
STFA 38 AD	11639	91971	2003.418	-0.4	↑0.5
STF 2426 AB		93273	1991.82	-0.1	0.0
SHJ 286	12007	93717	2003.418	-0.7	-0.1
STTA 178		94624	1991.57	-0.2	0.0
STT 588 AB		95447	2014.14	-0.8	-1.4
* STFA 43 AB	12546	95947	2003.418	↑0.5	↑0.2
STFA 46 AB	12815	96895	2003.628	-1.2	↑0.9
STF 2578 AB	12893	97228	2013.637	-1.6	-0.4
WEB 9 AB		98510	1991.47	0.0	↑0.3
STFA 50 AC	13554	99675	1991.72	-0.3	↑1.7
STFA 50 AD	13554	99675	1991.72	-0.5	+0.2
ENG 72 AB		99770	1991.61	+0.1	+0.2
HO 588 AB	13630	99967	2003.629	-0.2	+0.5
STTA 205		(3155 00153)	1991.65	+0.5	+0.6
STF 2806 AB	15032	106032	1991.50	+2.5	+0.1
STFA 57 AB		106515	1991.73	-0.2	+0.8
STF 2816 AC	15184	106886	2007.8672	-2.2	+0.1
STF 2816 AD	15184	106886	2003.620	0.0	+1.0
STF 2840 AB	15405	107930	2003.621	+0.7	+0.2
S 800 AB	15434	108073	1991.61	0.0	0.0
STF 2873 AB	15571	108456	2012.7705	-0.1	-0.3
STT 461 AD	15601	108925	1991.62	-2.1	-0.4
STT 461 AE	15601	108925	1991.61	-0.3	-0.3
STT 461 AC	15601	108925	1991.43	0.0	-0.9
STF 2872 AB	15670	(3981 01587)	1991.68	-1.3	↑0.8
STF 2883	15719	109475	2003.621	↑0.7	-0.2
STF 2893	15764	109659	2003.629	0.0	↑0.1
STF 2894 AB	15828	110171	1991.48	↑0.4	↑0.3
STFA 58 AC	15987	110991	2003.629	↑0.2	-0.2
STF 2922 AB	16095	111546	2003.625	0.0	↑0.3
A 1469 AD	16095	111546	1991.47	-1.3	0.0
A 1469 AE	16095	111546	1991.65	0.0	-0.2

S 813 AB	16148	111841	1991.46	-1.9	1.2
STT 480	16260	(3992 00747)	1991.64	0.0	-0.1
STTA 238 AB		112970	1991.72	0.0	-0.4
STF 2960 AC	16381	113281	1991.41	-1.2	-0.6
STT 486	16481	113853	2003.629	-0.4	1.0

*STT 588 - significant proper motion - most recent WDS measure used. All Residuals: observed (NW) - latest catalogue measurement