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SPECKLE INTERFEROMETRY AT THE U.S. NAVAL OBSERVATORY. XIX

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ABSTRACT

The results of 2916 intensified CCD observations of double stars, made with the 26 inch refractor of the U.S. Naval Observatory, are presented. Each observation of a system represents a combination of over two thousand short-exposure images. These observations are averaged into 1584 mean relative positions and range in separation from 0$''$.54 to 98$''$.09, with a median separation of 11$''$.73. This is the 19th in this series of papers and covers the period 2012 January 5 through 2012 December 18. Also presented are 10 pairs that are reported for the first time, 17 pairs that appear to be lost, linear elements for 18 pairs, and orbital elements for 2 additional pairs.

Key words: binaries: general – binaries: visual

Online-only material: color figure, machine-readable and VO tables

1. INTRODUCTION

This is the 19th in a series of papers from the U.S. Naval Observatory's speckle interferometry program, presenting results of observations obtained at the USNO 26 inch telescope in Washington, DC (see, most recently, Mason et al. 2012). Over 27,000 mean positions have now resulted from this program since its inception by Charles Worley, Geoff Douglass, and colleagues in the early 1990s (see Douglass et al. 1997).

From 2012 January 5 through 2012 December 18, the 26 inch telescope was used on 63 of 246 (26%) scheduled nights. While most nights were lost due to weather conditions, time was also lost due to equipment upgrades, mechanical issues, and to a lack of observing personnel. With the primary camera off-site, all observations were obtained with the secondary camera, described in Mason et al. (2007).

Most of the systems observed with this camera have separations well beyond the regime in which there is any expectation of isoplanicity, so we classify the observing technique for all of these measures as just "CCD astrometry," rather than speckle interferometry. Despite this classification, there is an expectation that the resulting measurements have smaller errors than classical long focus CCD astrometry. Each measurement is the result of many hundreds of correlations per frame, and up to several thousand frames per observation. This ensemble of observations is processed and measured using the conventional directed vector autocorrelation techniques used by the CHARA and USNO speckle teams for over 20 years.

Individual nightly totals varied substantially, from 4 to 111 objects per night (mean 43.8). The results yielded 2758 observations and 2812 resolutions. Observations of multiple star systems in a single CCD field gives the somewhat non-intuitive result where the number of resolutions exceed the number of observations. After removing marginal observations, calibration data, tests, and "questionable measures" a total of 2553 measurements remained. These "questionable measures" are not of inferior quality but represent significant differences from the last measure, often many decades ago. Before these measures are published they will need to be confirmed in a new observing season to account for any other errors such as pointing or other identification problems. The tabulated list of these is retained internally and forms a "high priority observing list" for subsequent observing seasons.

These 2553 measures were grouped into 1584 mean relative positions, including 11 confirmations of double stars with only one previous observation. If a pair is going through rapid motion during the calendar year we present, when possible, multiple means obtained when the pair is observable over the year.

Observing list construction and calibration procedures remain the same as those described for the "secondary" camera in Mason et al. (2007). This method also allowed us to use double stars to evaluate the observing system accuracy and precision by observation of pairs with well characterized orbital or linear solutions. Evaluation of the ensemble of tabulated $O - C$ values in Table 3 allows the error to be grossly characterized as $\pm 1^\circ.0$ in position angle and $\pm 1\% \rho$ in separation.

2. RESULTS

2.1. New Pairs

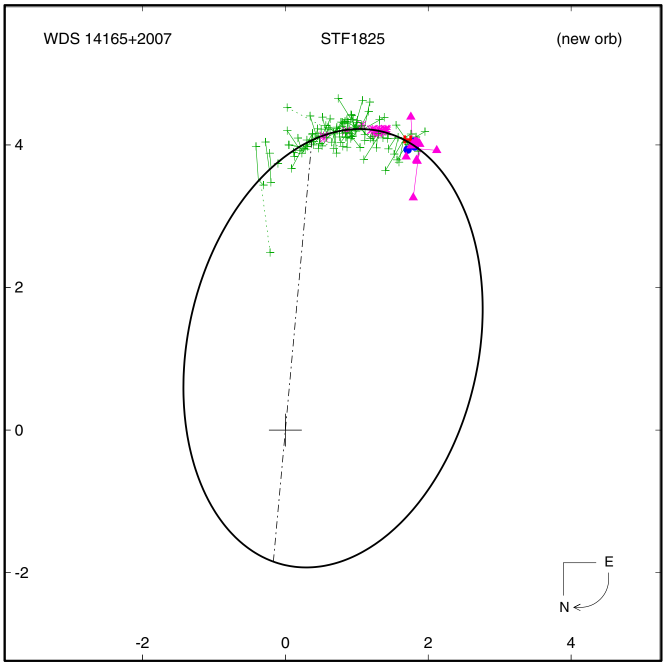
Table 1 presents coordinates and magnitude information from CDS[2] for 10 pairs which are presented here for the first time. All were observed as closer components to known systems or pairs in the same field of view. Column 1 gives the coordinates of the primary of the pair. Column 2 is the discoverer designation (where WSI = Washington Stellar Interferometer) number. Columns 3 and 4 give the visual magnitudes of the primary and secondary, and Column 5 notes the circumstance of the discovery. The mean double star positions (T, θ, and ρ) of these systems are given in Table 2.

2.1.1. CHARA 263

One of the pairs in Table 1 does not carry the WSI designation, but instead is designated CHR 263 (CHR = Center for High Angular Resolution Astronomy). This anonymous binary was observed in 1982 with the Mayall reflector on Kitt Peak with the CHARA Speckle Camera (see McAlister et al. 1987) as part of an effort to observe minor planets (see Roberts et al. 1995). It was noted as being "2′ south of minor planet Virginia"

[1] Summer intern.

[2] Magnitude information is from one of the catalogs queried in the Aladin sky atlas, operated at CDS, Strasbourg, France.



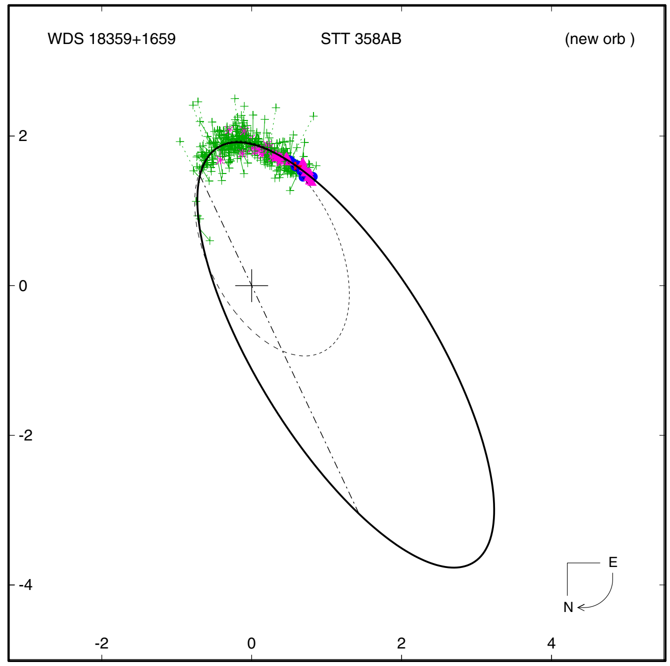


Figure 1. New orbital solutions, plotted together with all published data in the WDS database as well as the new data in Table 3. In each of these figures, micrometric observations are indicated by plus signs, interferometric measures by filled circles, *Hipparcos* measures are indicated by the letter "H." "$O - C$" lines connect each measure to its predicted position along the new orbit (shown as a thick solid line). Dashed "$O - C$" lines indicate measures given zero weight in the final solution. A dot-dashed line indicates the line of nodes, and a curved arrow in the lower right corner of each figure indicates the direction of orbital motion. In the case of WDS18359+1659 the previous published orbit (Heintz 1995) is shown as a dashed ellipse.

(A color version of this figure is available in the online journal.)

Table 1
New Pairs

Coordinates α, δ (2000)	Discoverer Designation	$\mathrm{Mag}_{\mathrm{primary}}$ (V)	$\mathrm{Mag}_{\mathrm{secondary}}$ (V)	Note
07 31 48.21 −03 09 20.9	WSI 31 AC	11.00	11.23	1
07 32 17.53 −02 20 03.4	WSI 141 AC	11.36	13.3	1
01 05 44.56 +20 04 23.7	WSI 144 AC	10.31	13.5	1
04 07 08.49 +19 01 31.5	WSI 145 Ba, Bb	12.3	13.3	1
19 51 14.13 +38 00 41.1	WSI 146 BC	12.5	13.0	1
19 58 34.28 +34 24 36.1	WSI 147 AC	12.31	13.3	1
21 51 53.96 −05 08 55.4	WSI 148 BC	11.33	13.3	1
22 15 59.03 −02 54 07.9	CHR 263	12.0	12.4	2
23 35 35.50 +43 44 44.6	WSI 149 BC	11.16	13.0	1
23 57 52.05 +56 42 25.6	WSI 150 BC	11.8	11.9	1

Notes.
1: Physicality status unknown, but closer than the known pair.
2: First measured by CHARA. See text.

Table 2
ICCD Measurements of Double Stars

WDS Desig. α, δ (2000)	Discoverer Designation	Epoch 2000.+	θ (°)	ρ (″)	n	Note
00004+7305	HJ 3231 AB	12.809	281.9	23.17	1	
00004+7305	HJ 3231 AC	12.809	296.3	44.72	1	
00012+1357	WNO 12	12.014	204.0	11.61	2	
00019+6319	BU 482 AB	12.915	342.0	4.14	3	
00019+6319	BU 482 AC	12.915	124.6	10.36	2	
00026+6606	STF 3053	12.907	70.6	15.14	2	
00036+4944	FOX 53	12.858	192.0	3.79	2	
00051+6323	HJ 1933	12.850	96.6	15.06	2	
00055+2736	J 865	12.784	77.6	1.43	1	
00055+2736	J 865 AC	12.784	8.4	25.35	1	

Notes.
A: This is the vector addition of measures of other pairs.
B: Pair originally published as BVD 45 (Benavides et al. 2010), but with incorrect sign given to declination. Pair later "rediscovered" and published with correct declination; this latter discoverer designation has been maintained.
C: Confirming observation.
D: Motion non-linear, but insufficient for an orbital solution at this time.
E: The close pair, CHR 84Aa, Ab (unresolved here), recently had a combined solution orbit determined yielding masses of $\mathcal{M}_a = 0.802 \pm 0.055\ \mathcal{M}_\odot$, $\mathcal{M}_b = 0.622 \pm 0.053\ \mathcal{M}_\odot$ and an orbital parallax of 28.26 ± 1.70 milliarcseconds (mas). See C. D. Farrington et al. (2014, in preparation).
F: First measured by CHARA. See text.
$N = 55$–108: Number of years since last measure.

(This table is available in its entirety in machine-readable and Virtual Observatory (VO) forms in the online journal. A portion is shown here for guidance regarding its form and content.)

and upon reduction this unpublished and unidentified pair was given the tongue-in-cheek moniker "Carolina" (i.e., south of Virginia). In 2011 the celestial location of Virginia at the time of the speckle observation was provided by James Hilton of the USNO Astronomical Applications Department and the pair was added to our observing list. This unknown pair is now confirmed 30 yr after the initial unpublished resolution. Coincidentally, MP (Minor Planet) 50 Virginia was discovered by James Ferguson at the Naval Observatory at its former location in Foggy Bottom on 1857 October 4.

2.2. *Measures of Known Pairs*

Table 2 presents the mean relative position of the members of 1359 systems having no published orbital or rectilinear elements. The first two columns identify the system by providing its epoch-2000 coordinates and discovery designation. Columns 3 through 5 give the epoch of observation (expressed as a fractional Besselian year), the position angle (in degrees), and the separation (in seconds of arc). Note that the position angle,

Table 3
Measurements of Systems with Orbits or Linear Solutions

WDS Desig. α, δ (2000)	Discoverer Designation	Epoch 2000.+	θ (°)	ρ (″)	n	$O-C$ (°)	$O-C$ (″)	Reference	Note
00057+4549	STT 547	12.858	186.9	6.02	3	−0.8	0.09	Popovic & Pavlovic (1996)	
						−0.3	−0.00	Kiyaeva et al. (2001)	
00057+4549	STT 547 AE	12.858	346.7	57.47	1	0.1	0.64	Hartkopf & Mason (2011b)	
00073+2058	HDS 12	12.014	7.8	1.93	1	−5.1	0.32	Hartkopf & Mason (2011b)	
00102+7507	HJ 1938	12.809	349.7	23.03	2	0.3	−0.08	Hartkopf & Mason (2011b)	
00175+0019	STF 23	12.017	217.5	9.83	4	−0.0	0.01	Hartkopf & Mason (2011b)	
		12.858	217.3	9.91	2	−0.0	−0.00	Hartkopf & Mason (2011b)	
00277−1625	HJ 1968	12.029	234.0	35.64	3	0.2	−0.07	Hartkopf & Mason (2011b)	
		12.858	234.1	35.92	1	0.3	−0.05	Hartkopf & Mason (2011b)	
00360+2959	STF 42 AB	12.240	21.0	6.25	1	0.4	−0.04	Kiselev et al. (2009)	
	AC	12.022	287.1	35.03	3	0.5	−0.18	Hartkopf & Mason (2011b)	
	AC	12.832	287.1	35.49	2	0.1	0.04	Hartkopf & Mason (2011b)	
	AC	12.921	287.3	35.49	1	0.2	0.01	Hartkopf & Mason (2011b)	
00378+2443	J 923	12.025	265.4	22.20	4	0.1	0.01	Hartkopf & Mason (2011b)	
		12.858	265.5	22.35	2	0.2	0.00	Hartkopf & Mason (2011b)	
		12.921	265.5	22.34	1	0.2	−0.03	Hartkopf & Mason (2011b)	
00396+8445	HJ 1986	12.809	69.3	40.60	1	0.6	0.20	Hartkopf & Mason (2011b)	
00434−0054	STF 53	12.025	3.3	51.00	2	0.0	−0.05	Hartkopf & Mason (2011b)	
		12.858	3.4	51.00	1	0.0	−0.25	Hartkopf & Mason (2011b)	
00502+1150	STF 63	12.032	249.4	32.69	2	0.7	−0.06	Hartkopf & Mason (2011b)	
		12.858	249.4	32.76	1	0.6	−0.11	Hartkopf & Mason (2011b)	
		12.932	249.4	32.84	1	0.6	−0.04	Hartkopf & Mason (2011b)	
00521+1036	STF 67	12.014	349.8	2.19	3	−0.2	−0.09	Hartkopf & Mason (2011a)	
01291+2143	HO 9	12.019	42.7	52.47	2	−0.0	−0.13	Hartkopf & Mason (2011b)	
		12.858	42.3	52.32	1	0.1	−0.12	Hartkopf & Mason (2011b)	
01399+1515	STF 142	12.025	66.4	22.13	4	0.1	−0.04	Hartkopf & Mason (2011b)	
		12.858	66.7	22.35	2	0.1	0.02	Hartkopf & Mason (2011b)	
01459+7142	HJ 1089	12.809	89.2	26.34	2	0.3	−0.24	Mason et al. (2012)	
01467+3310	STF 158	12.858	270.1	2.08	3	−2.3	0.03	Hartkopf & Mason (2011a)	
01510+2107	STF 175	12.025	359.3	27.81	4	0.2	−0.01	Hartkopf & Mason (2011b)	
		12.862	359.4	27.91	4	0.2	0.00	Hartkopf & Mason (2011b)	
		12.967	359.4	27.85	1	0.2	−0.07	Hartkopf & Mason (2011b)	
01522+6627	STF 167	12.915	313.9	31.42	1	0.5	−0.18	Hartkopf & Mason (2011b)	
01543−1543	GAL 314	12.019	1.0	35.82	2	0.2	−0.04	Hartkopf & Mason (2011b)	
		12.860	0.6	35.82	2	0.2	−0.20	Hartkopf & Mason (2011b)	
01559+0151	STF 186	12.014	248.4	0.72	1	0.3	−0.09	Brendley & Mason (2007)	
02011+3518	STF 197	12.858	232.5	37.35	2	−0.1	−0.74	Hartkopf & Mason (2011b)	
02020+0246	STF 202	12.014	265.9	1.68	1	2.4	−0.08	Scardia (1983)	
02157+6740	ENG 10	12.850	327.0	24.79	2	0.6	0.01	Hartkopf & Mason (2011b)	
02213−1057	HJ 3495	12.021	313.1	41.17	2	0.3	0.07	Hartkopf & Mason (2011b)	
		12.866	313.0	41.19	1	0.2	−0.00	Hartkopf & Mason (2011b)	
02556+2652	STF 326	12.036	220.4	4.75	1	−0.4	−0.18	Hartkopf & Mason (2011b)	
02558+3429	STF 325	12.036	147.6	22.47	2	0.6	−0.01	Hartkopf & Mason (2011b)	
		12.857	147.4	22.60	4	0.5	0.00	Hartkopf & Mason (2011b)	
		12.915	147.5	22.62	2	0.6	0.02	Hartkopf & Mason (2011b)	
02563+7253	STF 312	12.850	46.2	1.73	2	1.4	−0.08	Cvetkovic & Novakovic (2006)	
02592+2120	STF 333	12.066	209.1	1.35	1	−0.4	−0.01	Rica (2012)	
03344+2428	STF 412	12.913	353.0	0.72	1	0.7	−0.03	Scardia et al. (2002)	
03463+2411	S 437 AB, C	12.967	308.8	39.39	1	0.2	−0.37	Hartkopf & Mason (2011b)	
04100+8042	STF 460	12.102	143.6	0.68	1	−4.0	−0.01	Scardia (2003)	
04367+1930	STF 567	12.091	343.7	1.89	1	1.5	−0.14	Seymour et al. (2002)	
04382+7128	HJ 1146	12.102	37.9	26.97	1	0.0	−0.19	Hartkopf & Mason (2011b)	
04385+2656	STF 572	12.091	189.2	4.24	4	−0.1	−0.08	Hartkopf & Mason (2011b)	
04550+3411	HJ 351	12.132	77.6	18.72	1	0.5	0.34	Friedman et al. (2011)	
05079+0830	STT 98	12.132	296.1	0.74	1	0.4	−0.16	Scardia et al. (2008)	
05154+3241	STF 653	12.028	10.4	10.08	1	−0.5	0.03	Table 5	A
05245−0224	DA 5	12.094	77.6	1.65	1	0.2	−0.14	Hartkopf et al. (2012)	
05308+0557	STF 728	12.094	44.5	1.15	1	0.9	−0.14	Seymour & Hartkopf (1999)	
05329−0631	STF 735	12.094	350.2	57.56	1	0.2	−0.15	Hartkopf & Mason (2011b)	
05418+1933	STF 771	12.067	55.0	21.64	2	0.3	0.06	Hartkopf & Mason (2011b)	
05511+6545	STF 780 AC	12.102	148.0	12.20	2	1.0	−0.66	Hartkopf & Mason (2011b)	
05524+3618	AG 101	12.028	353.4	23.72	1	0.6	0.07	Hartkopf & Mason (2011b)	
06195+1220	STF 892	12.105	40.6	39.45	1	0.1	−0.02	Friedman et al. (2011)	
06278+2047	SHJ 70	12.127	202.3	24.93	1	−0.2	−0.07	Hartkopf & Mason (2011b)	
06323+5225	WOR 6	12.181	159.8	0.71	1	3.0	−0.05	Hartkopf & Mason (2009)	

Table 3
(Continued)

WDS Desig. α, δ (2000)	Discoverer Designation	Epoch 2000.+	θ (◦)	ρ (″)	n	O − C (◦)	O − C (″)	Reference	Note
06376+1211	S 529	12.132	131.6	53.38	2	0.2	−0.14	Hartkopf & Mason (2011b)	
06462+5927	STF 948	12.175	69.2	1.77	6	1.4	−0.11	Mason et al. (2006)	
06467+4335	SHJ 75	12.155	41.1	29.26	3	−0.1	−0.12	Hartkopf & Mason (2011b)	
06482+5542	STF 958	12.102	256.8	4.49	2	−0.2	−0.06	Kiselev et al. (2009)	
						0.3	0.01	Kiselev et al. (2009)	
07057+5245	STF 1009	12.182	148.0	4.24	3	0.1	−0.09	Hartkopf & Mason (2011b)	
07346+3153	STF 1110	12.105	56.2	4.58	1	0.9	−0.23	DeRosa et al. (2012)	
08122+1739	STF 1196	12.105	31.3	1.04	1	1.2	−0.04	Mason et al. (2006)	
08243+4457	STF 1217	12.255	242.2	29.04	2	0.1	0.39	Kiselev et al. (2009)	
						−0.4	0.19	Kiselev et al. (2009)	
08476+0001	STF 1281	12.236	310.5	52.33	1	0.0	0.03	Hartkopf & Mason (2011b)	
08554+7048	STF 1280	12.182	353.3	2.59	2	−0.6	−0.07	Heintz (1997)	
		12.255	353.1	2.61	2	−0.8	−0.07	Heintz (1997)	
09079−0708	STF 1316 AC	12.237	277.8	7.61	3	−0.1	0.04	Hartkopf & Mason (2011b)	
	BC	12.237	296.5	13.98	2	2.0	0.27	Friedman et al. (2012)	
10160+7928	STF 1409	12.256	194.5	19.01	2	0.6	−0.01	Hartkopf & Mason (2011b)	
10390+7839	FOX 167	12.256	51.2	15.25	2	0.3	0.03	Hartkopf & Mason (2011b)	
10517−0340	HDS 1551	12.302	322.5	2.69	2	−2.3	0.25	Table 5	
11131+4011	HJ 494	12.259	140.3	31.18	1	0.2	0.04	Table 5	
11170−0708	BU 600 AC	12.417	98.9	53.17	1	0.3	−0.18	Hartkopf & Mason (2011b)	
11182+3132	STF 1523	12.302	194.0	1.54	3	−0.6	−0.10	Mason et al. (1995)	
		12.417	192.1	1.56	2	−1.6	−0.09	Mason et al. (1995)	
11245+2037	STF 1537	12.286	357.8	2.19	1	0.0	−0.02	Table 5	
11268+0301	STF 1540	12.417	149.6	28.18	2	2.7	−0.46	Hopmann (1960)	
11296+1138	HJ 2572	12.286	171.7	38.94	1	0.2	−0.01	Table 5	
11456+0354	HJ 1196	12.302	204.1	45.78	1	−0.1	−0.02	Hartkopf & Mason (2011b)	
		12.417	204.2	45.72	1	−0.0	−0.10	Hartkopf & Mason (2011b)	
12095−1151	STF 1604 AB	12.417	89.1	8.88	1	0.7	−0.33	Hartkopf & Mason (2011b)	
12095−1151	STF 1604 AC	12.417	11.7	10.14	1	−0.2	−0.06	Hartkopf & Mason (2011b)	
12095−1151	STF 1604 BC	12.417	324.8	11.97	4	0.4	0.00	Friedman et al. (2012)	
12272+2701	STF 1643	12.417	4.6	2.61	2	0.2	−0.10	Olevic & Cvetkovic (2003)	
						−0.6	−0.16	Hartkopf & Mason (2011b)	
						0.2	−0.12	Mason et al. (2004a	
12417−0127	STF 1670	12.302	13.5	1.72	2	0.0	−0.11	Scardia et al. (2007)	
		12.417	12.9	1.73	1	−0.2	−0.13	Scardia et al. (2007)	
13005−0604	HJ 1224	12.302	283.4	16.50	2	−0.3	−0.12	Hartkopf & Mason (2011b)	
13084+1529	STF 1722	12.415	336.8	2.54	1	0.7	−0.12	Table 5	
13092+0848	A 1786	12.414	96.0	13.84	1	0.2	−0.10	Table 5	
13169+1701	BU 800	12.415	104.6	7.23	1	−0.2	−0.47	Hale (1994)	
13550−0804	STF 1788	12.141	99.9	3.55	2	0.3	−0.02	Hopmann (1970)	
14165+2007	STF 1825	12.439	153.9	4.20	1	−0.4	−0.16	Table 4	
14287−1012	STF 1847	12.124	270.3	36.74	2	0.1	−0.17	Hartkopf & Mason (2011b)	
		12.451	270.3	36.80	2	0.1	−0.15	Hartkopf & Mason (2011b)	
14307+8308	LDS 1800	12.486	240.1	1.79	2	17.2	0.21	Hartkopf & Mason (2011b)	
14407+1625	STF 1864	12.453	111.4	5.25	1	0.4	−0.26	Table 5	
14463+0939	STF 1879	12.453	83.5	1.61	1	−0.1	−0.11	Mason et al. (1999)	
14514+1906	STF 1888	12.453	306.2	5.66	2	0.3	−0.18	Söderhjelm (1999)	
14516+1519	HU 1153	12.453	295.7	2.97	1	−0.0	−0.24	Hartkopf & Mason (2011b)	
14595+5510	STI 2317	12.486	123.3	34.04	1	−0.1	−0.01	Hartkopf & Mason (2011b)	
15006+1606	KU 107	12.469	358.5	57.69	1	−0.1	0.08	Table 5	
15038+4739	STF 1909	12.486	62.7	1.24	2	−0.3	−0.09	Zirm (2011)	
15049+1014	WFC 161	12.469	84.3	36.88	1	−0.2	−0.32	Table 5	
15111+4424	SKF 10	12.486	281.2	13.26	2	0.1	0.22	Friedman et al. (2011)	
15230+1122	AG 347	12.486	11.8	24.63	2	−0.4	0.05	Table 5	
15232+3017	STF 1937	12.120	184.4	0.59	1	−0.0	−0.06	Muterspaugh et al. (2010)	
15249+1359	HJ 252 AC	12.486	72.4	51.01	1	0.0	−0.32	Table 5	
15280+1442	STF 1945	12.120	312.6	40.89	1	−0.1	−0.72	Hartkopf & Mason (2011b)	
		12.464	312.6	41.13	4	−0.2	−0.51	Hartkopf & Mason (2011b)	
	AC	12.351	306.9	49.03	4	−0.1	−0.04	Hartkopf & Mason (2011b)	
15348+1032	STF 1954	12.486	172.5	3.94	2	0.1	−0.04	Mason et al. (2004a)	
15382+3615	HU 1167 AB	12.486	79.3	1.22	1	−1.8	−0.03	Drummond et al. (1995)	
15382+3615	STF 1964 CD	12.486	20.7	1.47	2	1.3	−0.04	Drummond et al. (1995)	
15598+1723	STF 1993	12.491	42.4	20.38	1	−0.3	−0.08	Hartkopf & Mason (2011b)	
16044−1122	STF 1998	12.568	359.7	0.93	4	−0.2	−0.08	Docobo & Ling (2009)	
	AC	12.568	47.3	6.91	1	3.1	−0.63	Zirm (2008)	

Table 3
(Continued)

WDS Desig. α, δ (2000)	Discoverer Designation	Epoch 2000.+	θ (◦)	ρ ($''$)	n	O − C (◦)	O − C ($''$)	Reference	Note
16060+1319	STF 2007	12.491	321.9	38.25	1	−0.1	0.01	Hartkopf & Mason (2011b)	
16081+1703	STF 2010	12.491	13.1	27.04	1	−0.3	−0.09	Hartkopf & Mason (2011b)	
16263+0211	BAL 1915 AC	12.568	8.0	50.17	1	−0.2	0.00	Hartkopf & Mason (2011b)	
17146+1423	STF 2140	12.469	103.7	4.60	2	0.5	−0.05	Baize (1978)	
17174+2501	SLE 24	12.469	15.8	39.88	1	−0.7	−0.11	Hartkopf & Mason (2011b)	
17275+1627	A 2184	12.579	30.4	1.91	1	−0.4	−0.02	Table 5	
17394−1546	HU 181	12.543	37.8	0.90	1	−5.4	−0.11	Hartkopf & Mason (2001)	
17462+1019	AG 356	12.543	215.8	14.38	2	0.1	−0.16	Friedman et al. (2012)	
18031−0811	STF 2262	12.696	286.9	1.46	2	1.0	−0.13	Söderhjelm (1999)	
18359+1659	STT 358	12.661	149.5	1.59	1	1.7	0.07	Heintz (1995)	
						0.0	−0.06	Table 4	
18393+0700	J 101	12.606	243.6	5.32	1	0.3	−0.12	Table 5	
18443+3940	STF 2382 AB	12.628	346.8	2.19	2	0.2	−0.17	Mason et al. (2004b)	
						0.4	−0.11	Novakovic & Todorovic (2006)	
18443+3940	STF 2383 CD	12.628	77.6	2.26	2	0.6	−0.12	Docobo & Costa (1984)	
18489+1615	STF 2400 A, BC	12.606	161.1	10.82	1	0.3	0.09	Table 5	
18575+5814	STF 2438	12.666	357.0	0.81	1	−0.6	−0.02	Hartkopf & Mason (2001)	
19059+3502	HZG 13	12.434	136.3	27.07	1	−0.3	0.04	Hartkopf & Mason (2011b)	
		12.926	136.4	27.07	2	−0.4	−0.03	Hartkopf & Mason (2011b)	
19121+4951	STF 2486	12.734	204.4	7.22	2	−0.2	−0.06	Hale (1994)	
19168+6742	STF 2514	12.434	350.7	23.04	2	−0.4	0.13	Hartkopf & Mason (2011b)	
		12.734	350.7	23.05	1	−0.4	0.10	Hartkopf & Mason (2011b)	
19179+2522	BUP 187	12.434	39.7	53.95	1	−0.0	−0.03	Hartkopf & Mason (2011b)	
		12.926	39.7	53.92	1	−0.0	0.08	Hartkopf & Mason (2011b)	
19249+2126	WSI 22	12.434	271.8	14.97	2	0.5	0.15	Hartkopf & Mason (2011b)	
19260+3555	BU 1286 AB	12.434	45.2	22.38	3	0.2	0.14	Hartkopf & Mason (2011b)	
		12.926	45.1	22.45	2	0.2	0.12	Hartkopf & Mason (2011b)	
	BC	12.680	210.1	20.20	8	−0.1	0.14	Hartkopf & Mason (2011b)	
19418+5032	STFA 46	12.628	133.1	39.66	1	−0.3	−0.05	Hauser & Marcy (1999)	
20020+2456	STT 395	12.702	126.1	0.73	1	0.1	−0.12	Zirm (2013)	
20111+1611	HZG 15 AD	12.434	256.8	35.99	1	−0.5	−0.40	Friedman et al. (2011)	
20182+2319	POU 4348	12.732	163.5	28.32	1	0.1	0.15	Friedman et al. (2011)	
20333+3323	HJ 1535 AC	12.434	193.1	31.48	1	−0.4	0.02	Table 5	
	AD	12.434	229.6	58.46	1	0.2	0.06	Hartkopf & Mason (2011b)	
	AD	12.858	229.7	58.46	1	0.3	−0.02	Hartkopf & Mason (2011b)	
	AD	12.926	229.7	58.49	1	0.3	−0.01	Hartkopf & Mason (2011b)	
20387+3838	STF 2708	12.434	322.9	56.19	1	0.1	0.01	Hartkopf & Mason (2011b)	
		12.858	323.1	56.24	1	0.2	−0.05	Hartkopf & Mason (2011b)	
		12.926	323.0	56.26	1	0.1	−0.05	Hartkopf & Mason (2011b)	
20396+4035	STT 410	12.666	4.6	0.83	1	0.6	−0.04	Hartkopf & Mason (2011a)	
20423+4549	STT 411	12.434	348.6	31.42	1	−0.2	0.07	Hartkopf & Mason (2011b)	
		12.666	348.7	31.47	1	−0.1	0.09	Hartkopf & Mason (2011b)	
20425+4916	ARG 39	12.434	181.8	14.70	2	−0.1	0.02	Hartkopf & Mason (2011b)	
		12.595	181.8	14.70	2	−0.1	0.00	Hartkopf & Mason (2011b)	
		12.666	181.9	14.74	1	0.0	0.03	Hartkopf & Mason (2011b)	
20450+1244	BU 64	12.781	352.4	0.62	2	−2.3	−0.03	Brendley & Hartkopf (2007)	
20467+1607	STF 2727	12.705	265.7	8.99	2	0.5	−0.03	Hale (1994)	
21008−0821	BU 678	12.781	258.1	2.72	1	−4.9	−0.14	Seymour et al. (2002)	
21069+3845	STF 2758	12.858	152.1	31.39	2	0.6	−0.04	Gorshanov et al. (2006)	
21124−1500	H 1 47	12.492	309.3	4.18	2	20.0	0.95	Hopmann (1974)	
						0.6	0.02	Hartkopf & Mason (2011b)	
21186+1134	BU 163	12.697	258.1	0.79	1	−0.3	−0.05	Fekel et al. (1997)	
21200+5259	STF 2789	12.595	113.9	6.85	2	−0.1	−0.03	Kiselev et al. (2009)	
						−0.5	0.12	Kiselev et al. (2009)	
21208+3227	STT 437	12.651	19.4	2.31	4	0.3	−0.10	Hartkopf & Mason (2011a)	
21238−0635	S 788	12.492	92.8	56.89	1	−0.1	−0.50	Hartkopf & Mason (2011b)	
		12.697	92.8	56.95	1	−0.1	−0.47	Hartkopf & Mason (2011b)	
		12.703	92.8	56.94	2	−0.1	−0.48	Hartkopf & Mason (2011b)	
		12.781	92.8	56.92	1	−0.0	−0.50	Hartkopf & Mason (2011b)	
		12.859	92.8	56.94	2	−0.1	−0.50	Hartkopf & Mason (2011b)	
		12.934	92.8	56.94	1	−0.1	−0.50	Hartkopf & Mason (2011b)	
21289+1105	STF 2799	12.492	260.8	1.67	2	1.4	−0.19	Hartkopf & Mason (2011a)	
21296+3625	ES 258	12.705	35.0	10.15	2	−0.1	0.00	Hartkopf & Mason (2011b)	
		12.858	35.0	10.11	2	−0.1	−0.02	Hartkopf & Mason (2011b)	
		12.926	35.0	10.08	2	−0.2	−0.04	Hartkopf & Mason (2011b)	

Table 3
(Continued)

WDS Desig. α, δ (2000)	Discoverer Designation	Epoch 2000.+	θ (◦)	ρ (″)	n	O − C (◦)	O − C (″)	Reference	Note
21337+3728	SEI 1526	12.705	159.8	25.43	2	1.2	0.11	Hartkopf & Mason (2011b)	
		12.858	159.9	25.11	2	1.4	−0.23	Hartkopf & Mason (2011b)	
		12.926	160.0	25.14	2	1.4	−0.21	Hartkopf & Mason (2011b)	
21434−0605	SCA 90	12.702	261.5	41.19	1	0.4	−0.89	Hartkopf & Mason (2011b)	
21436−1108	LV 10	12.702	352.0	0.96	1	−2.3	0.12	Seymour et al. (2002)	
21441+2845	STF 2822	12.667	316.4	1.60	1	−2.4	−0.00	Heintz (1995)	
21520+5548	STF 2840	12.595	196.0	17.67	2	0.2	−0.08	Hartkopf & Mason (2011b)	
21582+8252	STF 2873	12.735	66.6	13.76	2	0.4	0.02	Grosheva (2006)	
						0.5	0.03	Grosheva (2006)	
22038+6438	STF 2863	12.849	275.0	8.00	2	1.1	−0.38	Zeller (1965)	B
22086+5917	STF 2872 BC	12.849	297.3	0.75	1	−0.3	−0.06	Seymour et al. (2002)	
22143+1711	STF 2877	12.667	23.4	23.47	1	0.1	0.34	Hartkopf & Mason (2011b)	
		12.866	23.6	23.30	1	0.3	0.15	Hartkopf & Mason (2011b)	
22159+5440	BU 377	12.907	57.7	32.43	1	−1.9	−3.67	Hartkopf & Mason (2011b)	
	AC	12.907	46.1	30.33	1	−4.9	−3.69	Friedman et al. (2011)	
22288−0001	STF 2909	12.492	167.0	2.03	2	−1.0	−0.16	Scardia et al. (2010)	
22378+3641	ES 216	12.874	37.1	52.47	1	−0.0	−0.17	Hartkopf & Mason (2011b)	
22400+0113	A 2099	12.866	165.0	0.70	1	0.9	−0.09	Hartkopf & Mason (2010)	
22435+4602	STT 477	12.858	261.1	21.65	1	0.1	−0.02	Hartkopf & Mason (2011b)	
22478−0414	STF 2944 AB	12.781	302.0	1.80	1	−0.1	−0.07	Zirm (2007)	
	AC	12.781	86.5	59.99	1	0.1	−0.33	Hartkopf & Mason (2011b)	
	AC	12.866	86.7	60.34	1	0.3	0.00	Hartkopf & Mason (2011b)	
	AC	12.926	86.4	59.97	1	0.1	−0.38	Hartkopf & Mason (2011b)	
	BC	12.781	85.6	61.57	1	−1.7	−0.65	Hartkopf & Mason (2011b)	A
22490+6834	STF 2947	12.735	55.8	4.65	2	0.4	−0.01	Hartkopf & Mason (2011b)	
22557+1547	HU 987	12.858	77.6	1.08	1	−0.4	−0.04	Brendley & Hartkopf (2007)	
23045+3123	ES 396	12.868	303.5	34.34	4	−0.0	0.22	Hartkopf & Mason (2011b)	
		12.926	303.5	34.35	2	0.0	0.21	Hartkopf & Mason (2011b)	
23097+1512	STF 2983	12.862	269.6	39.02	2	0.1	−0.58	Hartkopf & Mason (2011b)	
		12.926	269.7	38.94	1	0.2	−0.66	Hartkopf & Mason (2011b)	
23186+6807	STF 3001	12.811	222.2	3.24	2	−0.1	−0.11	Docobo et al. (2003)	
23192+6131	ES 1863 AC	12.856	150.2	9.86	6	−0.2	0.32	Hartkopf & Mason (2011b)	
23208+0227	STF 3002	12.866	197.0	3.82	1	0.1	0.19	Hartkopf & Mason (2011b)	
23397−0440	HJ 990	12.866	278.0	46.12	1	0.2	−0.14	Hartkopf & Mason (2011b)	
23398−0420	HWE 99	12.866	66.6	46.71	1	−0.3	0.18	Hartkopf & Mason (2011b)	
23401+1258	HU 1325	12.953	30.4	0.80	1	−5.8	0.18	Olevic & Jovanovic (2001)	
						1.0	−0.05	Scardia (2003)	
23460−1841	H 2 24	12.913	135.5	6.62	2	0.2	−0.30	Table 5	
23536+5131	STTA 251	12.932	207.9	47.67	2	0.3	−0.10	Hartkopf & Mason (2011b)	
23595+3343	STF 3050	12.795	338.2	2.23	1	−0.0	−0.09	Hartkopf & Mason (2011a)	
23596−0748	BU 731	12.913	296.6	1.62	1	−0.6	−0.05	Table 5	

Notes.
A: This is the vector addition of measures of other pairs.
B: The close pair, MCA 69Aa, Ab (unresolved here), recently had a combined solution orbit determined yielding masses of $\mathcal{M}_a = 1.045 \pm 0.031\ \mathcal{M}_\odot$, $\mathcal{M}_b = 0.408 \pm 0.066\ \mathcal{M}_\odot$ and an orbital parallax of 38.10 ± 2.81 milliarcseconds (mas). See C. D. Farrington et al. (2014, in preparation).

Table 4
New Orbital Elements

Element	Unit	HR 5346	HR 6981
WDS	α, δ (2000)	14165+2007	18359+1659
Discoverer designation		STF1825	STT 358 AB
Period (P)	years	755.6	1109.8
Semimajor axis (a'')	arcsec	3.205	3.923
Inclination (i)	(°)	133.7	109.6
Longitude node (Ω)	(°)	174.8	205.2
Epoch periastron (T_0)	years	1661.6	1836.4
Eccentricity (e)		0.453	0.664
Longitude periastron (ω)	(°)	213.9	301.8
Orbit grade		5	4

measured from north through east, has not been corrected for precession, and is thus based on the equinox for the epoch of observation. Objects whose measures are of lower quality are indicated by colons following the position angle and separation. These lower-quality observations may be due to one or more of the following factors: close separation, large magnitude difference, one or both components being very faint, a large zenith distance, and poor seeing or transparency. They are included primarily due to either the confirming nature of the observation or the number of years since the last measured position. The sixth column indicates the number of independent measurements (i.e., observations obtained on different nights) contained in the mean, and the seventh column flags any notes. The 1359 measurements in Table 2 have a mean separation of 16.″92, and a median separation of 11.″14.

Table 5
New Linear Elements

WDS α, δ (2000)	Discoverer Designation	x_0 ($''$)	a_x ($''$ yr^{-1})	y_0 ($''$)	a_y ($''$ yr^{-1})	T_0 (yr)	ρ_0 ($''$)	θ_0 (deg)
05154+3241	STF 653 AB	3.736	0.02998	−9.115	0.0123	2074.672	9.851	22.29
10517−0340	HDS 1551	0.515	0.15591	−0.916	0.0876	2026.167	1.051	29.32
11131+4011	HJ 494	7.630	0.05247	27.330	−0.0146	1778.458	28.375	164.40
11245+2037	STF 1537	0.764	0.00084	−0.348	0.0018	3028.755	0.840	65.50
11296+1138	HJ 2572	−8.912	0.05745	34.751	0.0147	1758.260	35.875	194.38
13084+1529	STF 1722	−0.539	0.00104	0.114	0.0049	2531.563	0.551	258.04
13092+0848	A 1786	0.020	0.09071	−0.176	0.0104	1861.110	0.177	6.56
14407+1625	STF 1864 AB	3.937	−0.00500	3.378	0.0058	2254.407	5.188	130.63
15006+1606	KU 107	13.445	−0.06413	−53.878	−0.0160	1781.644	55.530	14.01
15049+1014	WFC 161	0.020	0.48115	−3.750	0.0025	1936.876	3.750	0.30
15230+1122	AG 347	0.429	0.07230	−24.108	0.0013	1947.878	24.112	1.02
15249+1359	HJ 252 AC	36.274	0.04028	15.026	−0.0972	1699.689	39.263	112.50
17275+1627	A 2184 AB	−0.449	0.00983	−0.619	−0.0071	1867.765	0.765	324.07
18393+0700	J 101	0.291	−0.02309	1.212	0.0056	1790.391	1.246	166.48
18489+1615	STF 2400 A, BC	−1.340	0.03279	0.690	0.0637	1865.609	1.507	242.77
20333+3323	HJ 1535 AC	11.905	−0.14829	13.155	0.1342	1883.907	17.742	137.85
23460−1841	H 2 24	−0.984	0.00714	1.911	0.0037	1194.851	2.150	207.25
23596−0748	BU 731	−1.553	0.00088	−0.176	−0.0078	1937.605	1.563	276.45

Table 6
Orbit and Linear Ephemerides

WDS	Discoverer	2012.0		2014.0		2016.0		2018.0		2020.0	
α, δ (2000)	Designation	θ (°)	ρ ($''$)	θ (°)	ρ ($''$)	θ (°)	ρ ($''$)	θ (°)	ρ ($''$)	θ (°)	ρ ($''$)
05154+3241	STF 653 AB	10.6	10.059	11.0	10.046	11.4	10.033	11.7	10.021	12.1	10.009
10517−0340	HDS 1551	321.8	2.743	325.1	2.416	329.3	2.100	335.1	1.799	342.9	1.523
11131+4011	HJ 494	140.3	31.097	140.1	31.141	139.9	31.186	139.7	31.232	139.5	31.277
11245+2037	STF 1537	357.7	2.220	357.8	2.216	357.8	2.212	357.8	2.209	357.9	2.205
11296+1138	HJ 2572	171.6	38.904	171.5	38.950	171.3	38.996	171.1	39.043	171.0	39.089
13084+1529	STF 1722	336.1	2.669	336.1	2.659	336.0	2.649	336.0	2.639	335.9	2.630
13092+0848	A 1786	95.8	13.779	95.8	13.961	95.8	14.144	95.9	14.327	95.9	14.509
14165+2007	STF 1825	154.3	4.357	154.0	4.352	153.7	4.346	153.3	4.340	153.0	4.334
14407+1625	STF 1864 AB	110.9	5.512	111.0	5.506	111.2	5.501	111.3	5.496	111.5	5.491
15006+1606	KU 107	358.7	57.580	358.6	57.615	358.4	57.650	358.3	57.686	358.2	57.722
15049+1014	WFC 161	84.4	36.341	84.5	37.298	84.7	38.256	84.8	39.214	84.9	40.172
15230+1122	AG 347	11.9	24.554	12.2	24.581	12.6	24.610	12.9	24.639	13.2	24.669
15249+1359	HJ 252 AC	72.6	51.204	72.4	51.340	72.2	51.476	72.0	51.612	71.9	51.749
17275+1627	A 2184 AB	30.5	1.910	30.8	1.932	31.0	1.954	31.3	1.977	31.6	1.999
18359+1659	STT 358 AB	149.8	1.645	148.9	1.641	148.0	1.637	147.0	1.633	146.1	1.630
18393+0700	J 101	243.2	5.408	243.3	5.454	243.4	5.500	243.5	5.546	243.6	5.593
18489+1615	STF 2400 A, BC	160.9	10.598	160.8	10.740	160.7	10.882	160.6	11.024	160.5	11.166
20333+3323	HJ 1535 AC	193.1	31.162	193.6	31.491	194.0	31.823	194.4	32.155	194.8	32.490
23460−1841	H 2 24	135.4	6.907	135.3	6.922	135.3	6.937	135.3	6.953	135.2	6.968
23596−0748	BU 731	296.8	1.667	297.3	1.673	297.8	1.679	298.3	1.684	298.8	1.690

The most common note indicators are either "C," indicating a confirming observation, or a number (N) indicating the number of years since the system was last measured. This is only given for systems with $N \geqslant 50$ yr. Eleven systems are confirmed here. Since priority is given to both unconfirmed systems and to systems not observed recently, the time since last observation can be surprisingly large; for the systems in Table 2 the average time since the last observation is eight years (47 yr for those measures of reduced accuracy). Seventeen systems had not been observed in 50 yr or more and 4 had not been observed for at least a century. The maximum such time span was 108 yr for HJ 3085, last observed by Burnham (1906).

2.3. Orbit and Linear Calculations

Table 3 presents the mean relative positions for 225 systems with published orbital determinations or linear solutions. The first six columns are identical to the corresponding columns of Table 2. Columns 7 and 8 give $O - C$ residuals (in θ and ρ) to the determination referenced in Column 9. The reference is either to a published orbit or linear calculation. Notes follow in Column 9. The objects in Table 3 tend to be more frequently observed than those in Table 2. Here mean and median separations of 22.″12 and 20.″38 are determined, with a mean time interval since last observation of only 4.6 yr. For the subset of orbit pairs ($N =$ 70), the mean and median separations are 4.″35 and 1.″73 and the mean time interval since the last observation of 2.7 yr. In 11 cases, of possible solutions it is not yet possible to ascertain which is the preferred determination and additional residual lines are provided.

2.3.1. New Orbital Elements

New orbits are presented in Table 4. In this table, the pairs are identified by their WDS and discoverer designations. The orbital

Table 7
Double Stars not Found

Coordinate	Discoverer	Most Recent Published Observation			Published Magnitude		Notes
α, δ (2000)	Designation	Date	Position Angle θ (○)	Separation ρ (″)	Primary	Secondary	
00589+3230	SEI 10	1894	100	12.4	9.5	10.0	1
00595+3202	SEI 11	1894	359	8.5	10.0	10.5	1
02413+2659	L 55	1910	50	6.8	8.0	9.0	2
05347−0424	SE 4 AC	1859	86	51.5	7.7		3
05347−0424	SE 4 AD	1859	297	10.9	7.7	8.2	2
06336+0910	TDS 3923	1991	230	3.4	11.2	11.4	2
09342+0241	WAM 2	1932	193	3.4	11.1	11.5	2
10425−0231	BAL 525	1894	345	3.3	9.4	11.9	2
11205+1841	TDS 7797	1991	251	6.0	9.7	11.6	2
18129−1820	OL 163	1934	290	3.0	8.9	10.0	2
18188−1804	OL 104	1921	213	3.0	9.5	10.5	2
19296+7311	PAL 1 AB	1995	72	4.6	10.6		3
19432+0448	J 1290	1916	214	2.5	10.0	10.3	2
20051−1136	H 4 3	1780	10	25.0	6.3		3
21098+3143	ES 2440	1930	202	5.0	10.9	11.9	2
23512+5123	ALD 7	1916	202	4.2	10.	10.9	4
23569+2457	POU 5877	1897	22	17.2	10.6	11.8	2

Notes.
1: Neither component seen on POSS plate; may be flaws on AC Potsdam plate.
2: Companion not seen.
3: Secondary magnitude unknown. Due to discovery method should be observable.
4: Also not found by Heintz (1990) at Index Catalogue of Double Stars position.

elements follow giving the period (P in years), the semimajor axis (a″ in arcseconds), the inclination (i) and longitude of the node (Ω), both in degrees, the epoch of the most recent periastron passage (T_o in Besselian years), the eccentricity (e) and the longitude of periastron (ω in degrees). Following this is an evaluation of the orbit.

WDS18359+1659 (= STT 358) was beginning to exhibit systematic runoff from the orbit of Heintz (1995). Using the Orbit Catalog precepts (Hartkopf et al. 2001) the new orbit is evaluated as "preliminary," but does give a reasonable mass sum estimate of 1.74 $\mathcal{M}_\odot$(±2.50 $\mathcal{M}_\odot$) for an F8V and its companion. The *Hipparcos* parallax (30.41 ± 0.90 mas; van Leeuwen 2007) and new orbital elements imply a physical semimajor axis of 129 au.

WDS14165+2007 (= STF 1825) has its first orbit determination, evaluated as "indeterminate," presented here. The pair has long been thought physical due to the similarity of their proper motions. The mass sum estimate is also reasonable here: 2.00 $\mathcal{M}_\odot$ ± 0.28 $\mathcal{M}_\odot$ for an F6V and its companion. Similarly, the *Hipparcos* parallax (30.65 ± 0.64 mas; van Leeuwen 2007) and new orbital elements imply a physical semimajor axis of 105 au.

For both pairs, these elements may be most appropriately characterized as "improved but still provisional." In both cases, the orbits should be sufficient to provide reasonable ephemerides for the next decade, but these elements will all require correction over the course of a complete orbit before they can be considered even approximately correct. These orbits along with their data are presented in Figure 1.

2.3.2. New Linear Elements

Selecting out all observed pairs with either a 30° change in their position angle or a 30% change in separation since the first observation cataloged in the WDS (Mason et al. 2001) revealed many pairs whose motion seemed linear. Their apparent linear relative motions suggest that these pairs are either composed of physically unrelated stars or have very long orbital periods. Linear elements to these doubles are given in Table 5, where Columns 1 and 2 give the WDS and discoverer designations and Columns 3–9 list the seven linear elements: x_0 (zero point in x, in arcseconds), a_x (slope in x, in ″ yr^{-1}), y_0 (zero point in y, in arcseconds), a_y (slope in y, in ″ yr^{-1}), T_0 (time of closest apparent separation, in years), ρ_0 (closest apparent separation, in arcseconds), and θ_0 (position angle at T_0, in degrees). See Hartkopf & Mason (2011b) for a description of all terms.

Table 6 gives orbital and linear ephemerides for the pairs in Tables 4 and 5 over the years 2012 through 2020, in two-year increments. Columns 1 and 2 are the same identifiers as in Tables 4 and 5, while Columns 3+4, 5+6, etc., through 11+12 give predicted values of θ and ρ, respectively, for the years 2012.0, 2014.0, etc., through 2020.0.

2.4. Double Stars Not Found

Table 7 presents 17 systems which were observed but not detected. Possible reasons for nondetection include orbital or differential proper motion making the binary too close or too wide to resolve at the epoch of observation, a larger than expected Δm, incorrect pointing of the telescope, and misprints and/or errors in the original reporting paper. It is hoped that reporting these will encourage other double star astronomers to either provide corrections to the USNO observations or to verify the lack of detection. Notes to some of these pairs, highlighting some possible reasons for non-detection, are appended to the table. In all cases, the position angle, separation and magnitudes are from the discoverer of the pair.

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