The Astronomical Journal, 123:1023–1038, 2002 February

BINARY STAR ORBITS. II. PRELIMINARY FIRST ORBITS FOR 117 SYSTEMS

Diana M. Seymour,[1] Brian D. Mason, William I. Hartkopf, and Gary L. Wycoff
US Naval Observatory, 3450 Massachusetts Avenue, NW, Washington, DC 20392-5420; dseymour@fas.harvard.edu, bdm@draco.usno.navy.mil, wih@usno.navy.mil, glw@draco.usno.navy.mil
Received 2001 September 26; accepted 2001 October 29

ABSTRACT

Orbital elements are presented for 117 binary systems with no previous orbit calculation. For nearly all of these systems, these elements must be regarded as preliminary, but the ephemerides presented here should be relatively accurate over the next several decades. Further, the analysis of these systems should highlight the need for their continued observation by dedicated programs to improve the veracity of these elements.

Key words: binaries: general — binaries: visual

1. INTRODUCTION

As double star observing programs continue, investigation of systems whose motion years ago was indeterminate can now reveal Keplerian motion. A project was undertaken to examine systems in the Washington Double Star Catalog (WDS; Mason et al. 2001) and pinpoint those that, while having no published orbits, now show orbital motion. For 117 of these systems, the observational data were sufficient to calculate first orbits.

These orbits are not expected to be definitive; rather, they are meant to provide a baseline for future observations and orbit calculations. As most of these systems have too few data to be well defined, the ephemerides are expected to be more useful than the orbital elements in most cases. We calculate these orbits in part to encourage further observation of these systems, many of which have gone unobserved for a decade.

The systems considered as candidates for this project met three criteria. First, they did not have published orbits. Second, they needed a minimum of eight observations so as to avoid making broad pronouncements based on little data. Finally, they had to exhibit at least a 30° change in position angle or a 30% change in separation.

The observations of each candidate system were plotted so that each system could be visually examined. Some systems, which will be the subject of future analysis, displayed rectilinear motion, probably due to differential proper motion; others showed uncertain motion; still others appeared to be stationary. In the latter case, incorrect quadrant assignments or observational errors were responsible for their selection. Orbits were attempted only for those systems that visually displayed significant curvature.

Initial estimates of orbital period, epoch of periastron passage, and eccentricity (P, T_0, and e) are made, based on the motion indicated by the available data, along with grid step sizes for those elements. Weights of observations are assigned on the basis of telescope aperture and observing technique, as described in Hartkopf, Mason, & Worley (2001). Orbits are then calculated according to the "three-dimensional adaptive grid search technique," initially described by Hartkopf, McAlister, & Franz (1989) and modified as described by Mason, Douglass, & Hartkopf (1999). Briefly, the four Thiele-Innes elements (A, F, B, and G) are calculated by the method of least squares. From A, F, B, and G the other geometric elements (a, i, Ω, and ω) are calculated directly. As this procedure is performed, the initial values of P, T, and e are modified by an adaptive grid search. Over several iterations, observations are assigned new weights according to their rms errors and residuals, and the orbital elements eventually converge as the grid search narrows.

2. NEW ORBITS

Of the more than 84,000 systems in the WDS, 2302 systems with 54,718 observations satisfied the criteria enumerated in the previous section and were considered candidate systems. Of these, 255 initially appeared to display Keplerian motion. Closer examination of the data, before, during, and after attempts at calculating orbits, led to a final result of 117 serviceable orbits incorporating 3356 observations (see Figs. 1–10).

In sifting through these data, several hundred erroneous measures were discovered. Among those systems with orbits published here, 213 measures with flipped quadrants were found; these were corrected for the orbit calculations by adding or subtracting 180° from each measure as appropriate. An additional 422 measures with flipped quadrants were gleaned from systems whose orbits could not be calculated at this time. Wherever possible, these quadrant ambiguities were resolved using differential magnitude measurements. For most systems, where only a measure or two had quadrants inconsistent with the remainder, only these outliers were changed. Further, 15 measures reported angular separations so vastly different from other observations of the same system that they were removed entirely from system plots (for considerations of scaling) and were never incorporated into orbit calculations. Two of these belonged to systems with orbits published here (HU 1213 and HU 190). These measures have been flagged in the WDS as possibly erroneous.

The results of our orbit calculations are presented in Table 1. The first column shows the epoch J2000.0 coordinates of each system, with right ascension given to the nearest tenth of a minute of time and declination given to the nearest minute of arc. The second column gives the discoverer designation, with components specified if any additional ones are known to exist. The third through ninth

[1] Science and Engineering Apprenticeship Program intern.

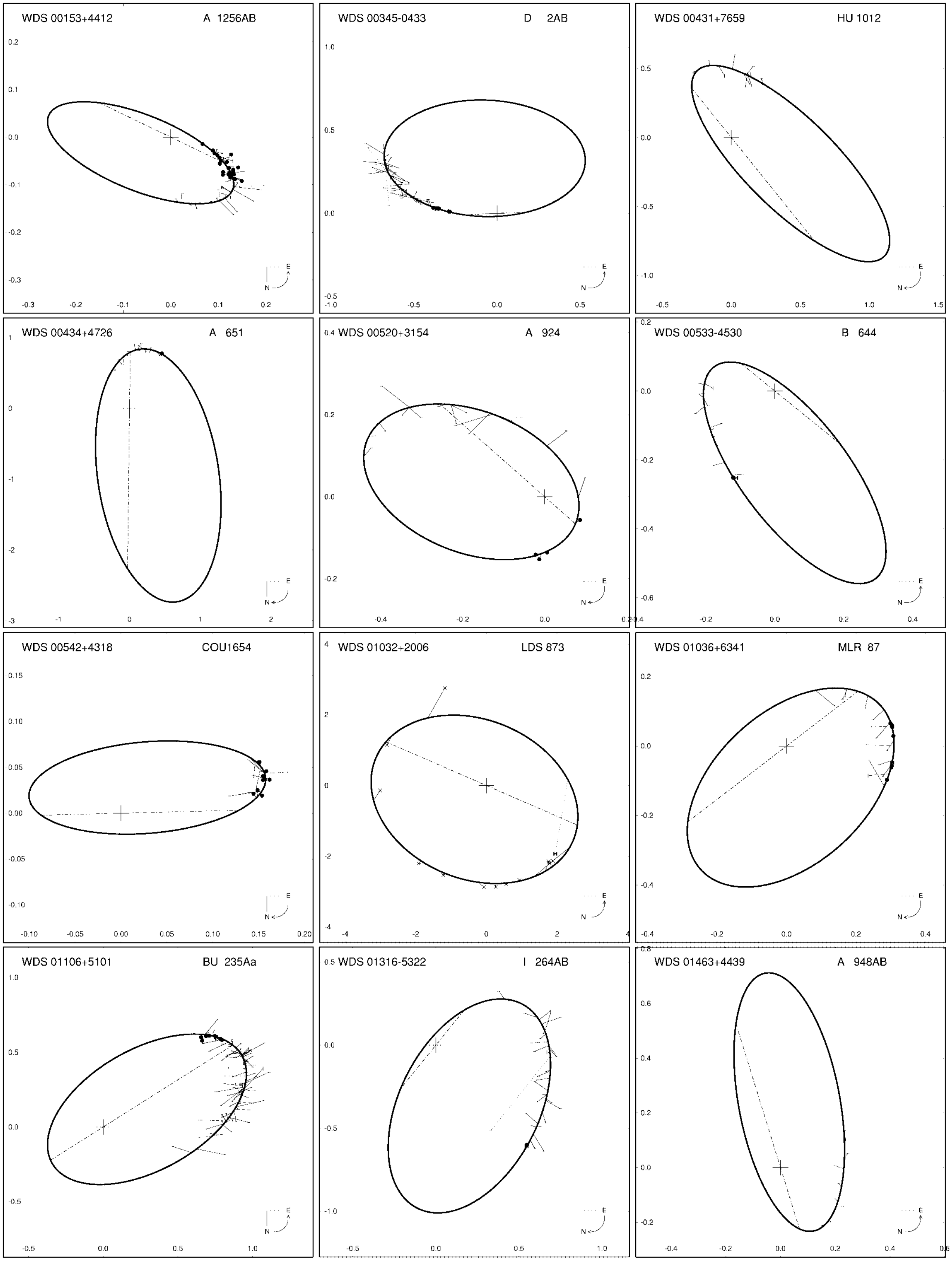

FIG. 1.—Orbital information for (*left to right and top to bottom*) 00153+4412 = A 1256 AB, 00345−0433 = D 2 AB, 00431+7659 = HU 1012, 00434+4726 = A 651, 00520+3154 = A 924, 00533−4530 = B 644, 00542+4318 = COU 1654, 01032+2006 = LDS 873, 01036+6341 = MLR 87, 01106+5101 = BU 235 Aa, 01316−5322 = I 264 AB, and 01463+4439 = A 948 AB. In this and subsequent figures, orbits are plotted as the path of the secondary star around the primary. Each observation (*plus signs*, visual measurements; *asterisks*, photographic measures; "H," *Hipparcos* measures; "T," Tycho measures; *filled circles*, speckle interferometry; *open circles*, optical interferometry) is connected to its predicted position by an $O-C$ line, which may be interpreted as an error bar; a dotted $O-C$ line signifies a zero-weighted measure. The line of nodes is the dash-dotted line passing through the primary star. The scale is in arcseconds.

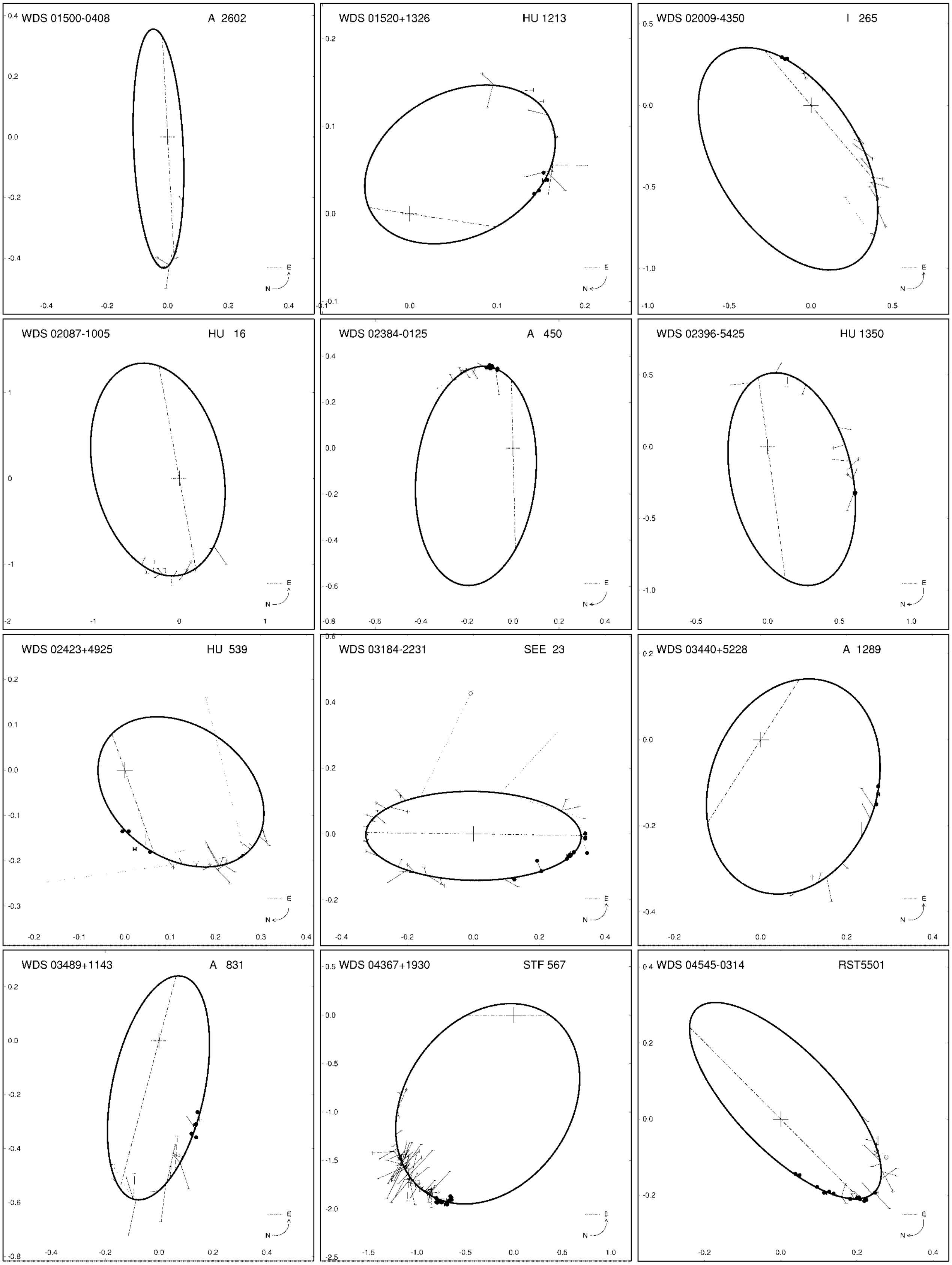

FIG. 2.—Same as Fig. 1, but for 01500−0408 = A 2602, 01520+1326 = HU 1213 (one zero-weighted measure has been omitted for purposes of scaling), 02009−4350 = I 265, 02087−1005 = HU 16, 02384−0125 = A 450, 02396−5425 = HU 1350, 02423+4925 = HU 539, 03184−2231 = SEE 23, 03440+5228 = A 1289, 03489+1143 = A 831, 04367+1930 = STF 567, and 04545−0314 = RST 5501.

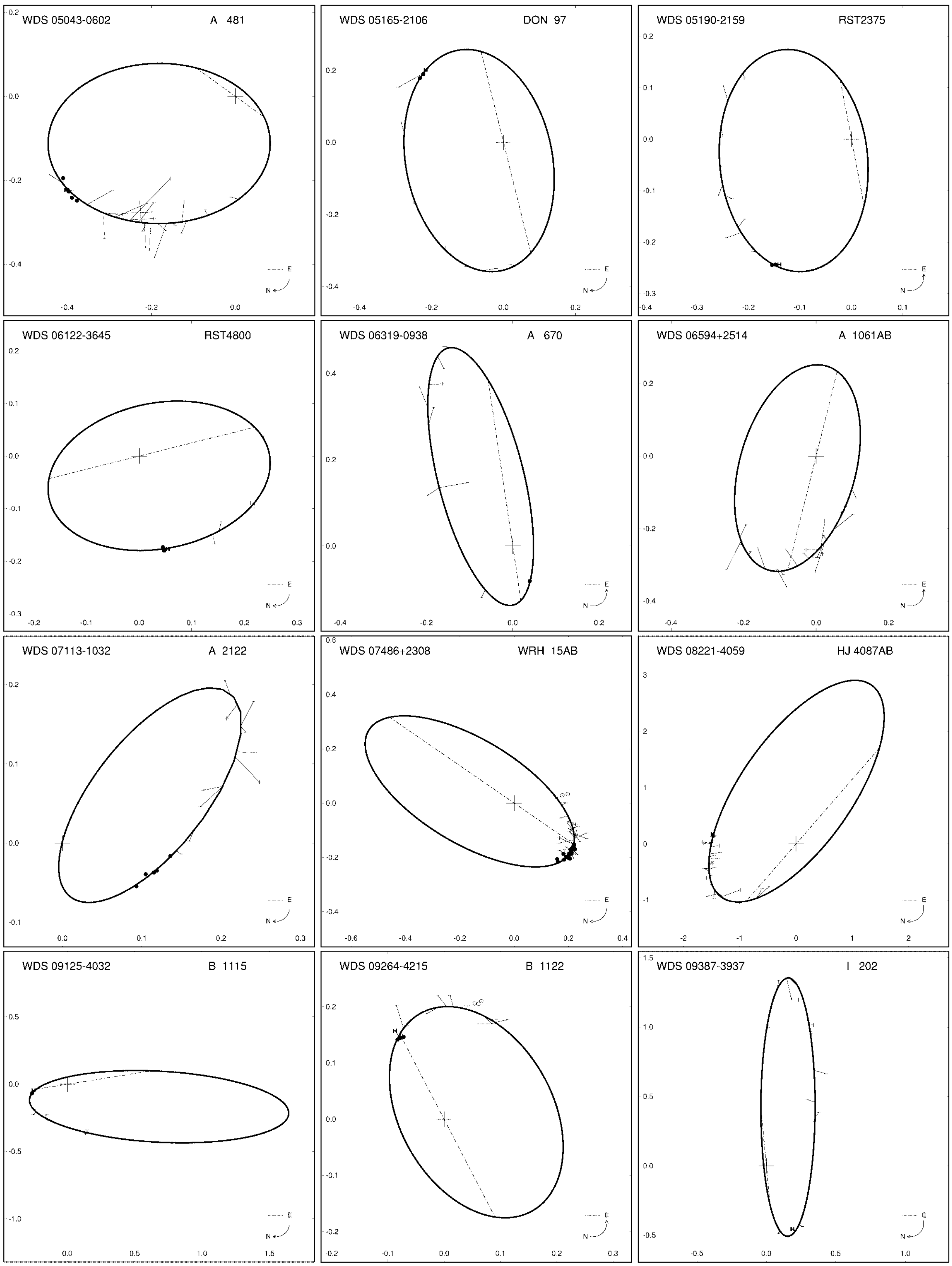

FIG. 3.—Same as Fig. 1, but for 05043−0602 = A 481, 05165−2106 = DON 97, 05190−2159 = RST 2375, 06122−3645 = RST 4800, 06319−0938 = A 670, 06594+2514 = A 1061 AB, 07113−1032 = A 2122, 07486+2308 = WRH 15 AB, 08221−4059 = HJ 4087 AB, 09125−4032 = B 1115, 09264−4215 = B 1122, and 09387−3937 = I 202.

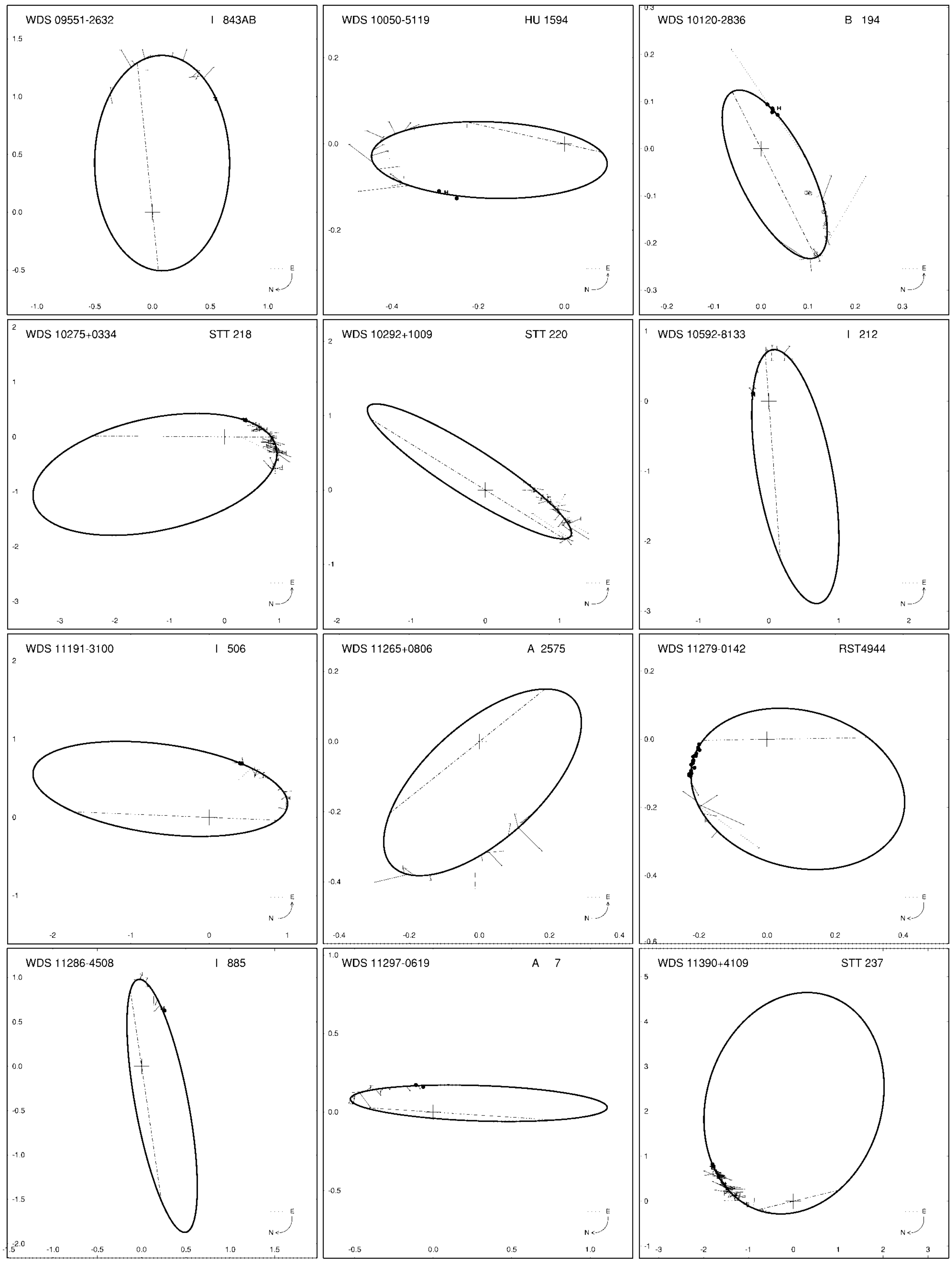

FIG. 4.—Same as Fig. 1, but for 09551−2632 = I 843 AB, 10050−5119 = HU 1594, 10120−2836 = B 194, 10275+0334 = STT 218, 10292+1009 = STT 220, 10592−8133 = I 212, 11191−3100 = I 506, 11265+0806 = A 2575, 11279−0142 = RST 4944, 11286−4508 = I 885, 11297−0619 = A 7, and 11390+4109 = STT 237.

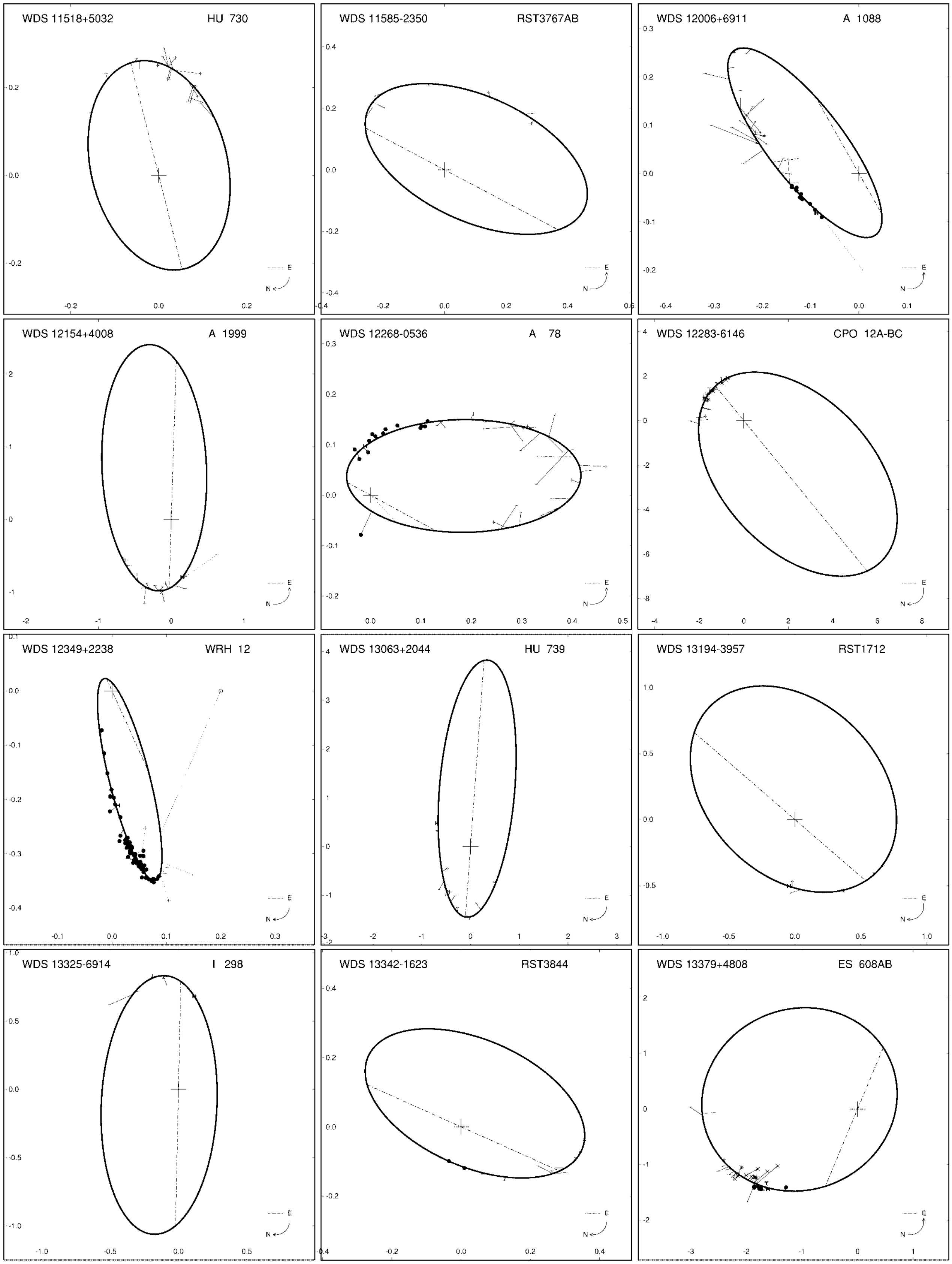

FIG. 5.—Same as Fig. 1, but for 11518+5032 = HU 730, 11585−2350 = RST 3767 AB, 12006+6911 = A 1088, 12154+4008 = A 1999, 12268−0536 = A 78, 12283−6146 = CPO 12 A-BC, 12349+2238 = WRH 12, 13063+2044 = HU 739, 13194−3957 = RST 1712, 13325−6914 = I 298, 13342−1623 = RST 3844, and 13379+4808 = ES 608 AB.

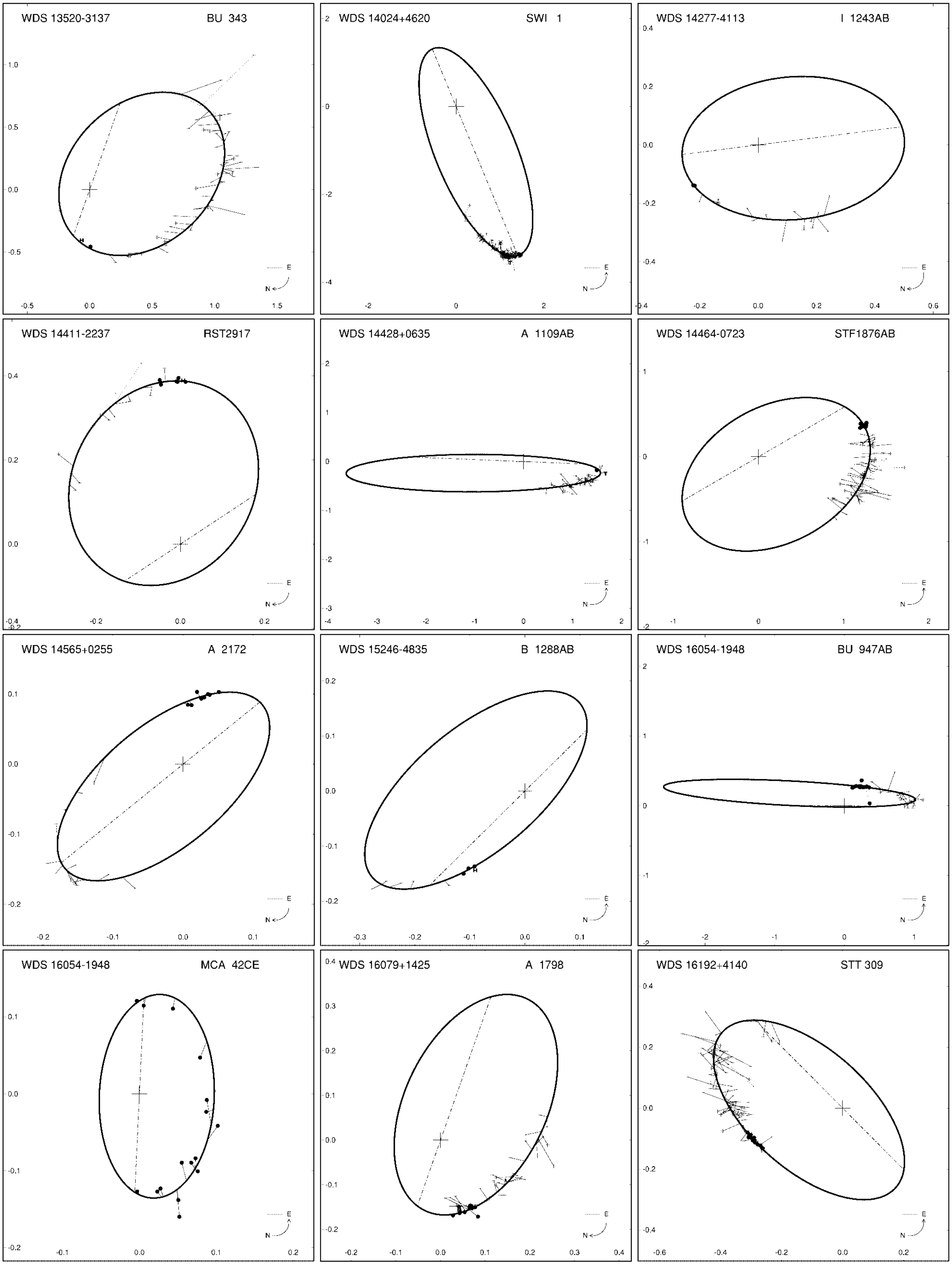

FIG. 6.—Same as Fig. 1, but for 13520−3137 = BU 343, 14024+4620 = SWI 1, 14277−4113 = I 1243 AB, 14411−2237 = RST 2917, 14428+0635 = A 1109 AB, 14464−0723 = STF 1876 AB, 14565+0255 = A 2172, 15246−4835 = B 1288 AB, 16054−1948 = BU 947 AB, 16054−1948 = MCA 42 CE, 16079+1425 = A 1798, and 16192+4140 = STT 309.

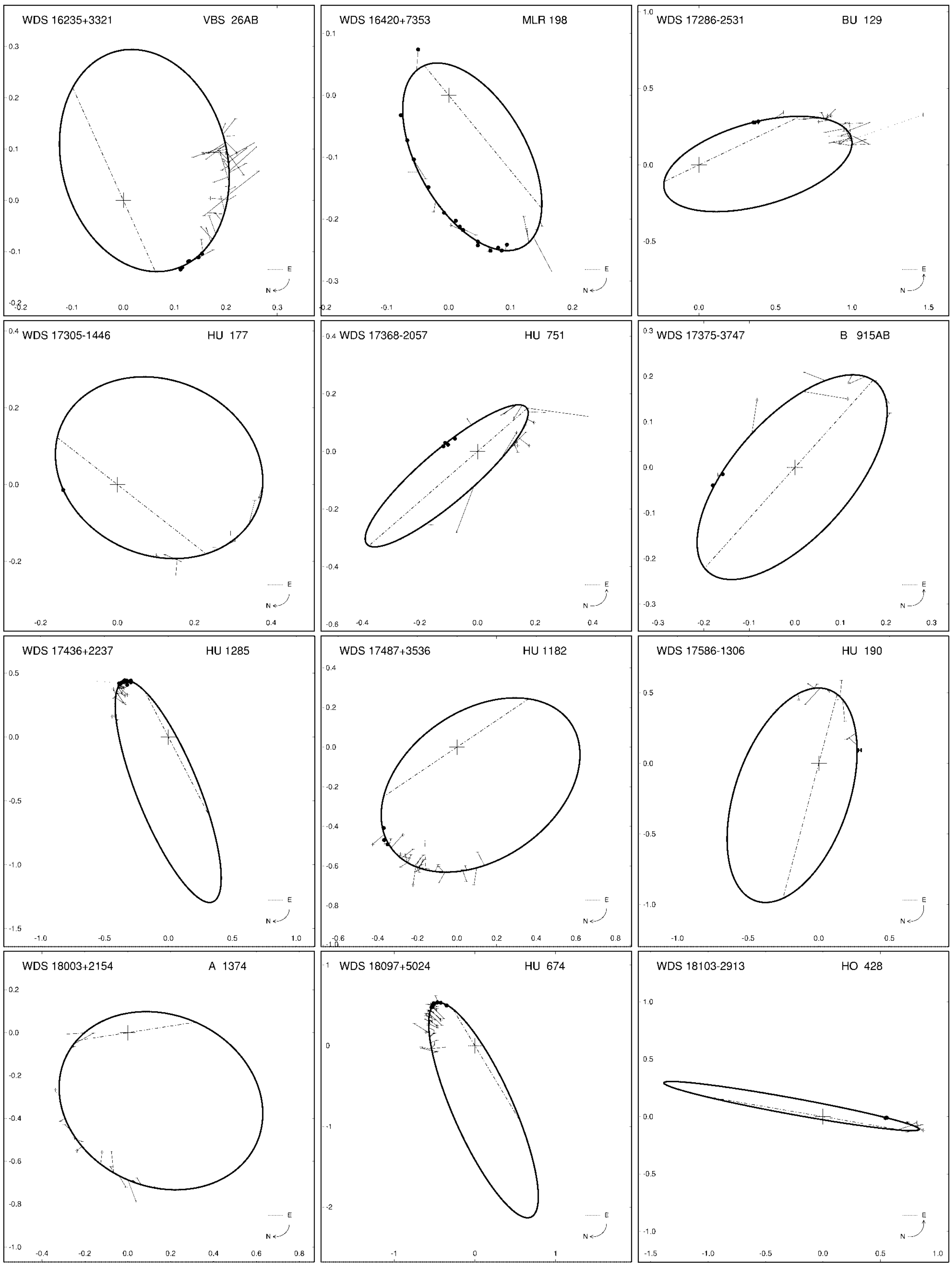

FIG. 7.—Same as Fig. 1, but for 16235+3321 = VBS 26 AB, 16420+7353 = MLR 198, 17286−2531 = BU 129, 17305−1446 = HU 177, 17368−2057 = HU 751, 17375−3747 = B 915 AB, 17436+2237 = HU 1285, 17487+3536 = HU 1182, 17586−1306 = HU 190 (one zero-weighted measure has been omitted for purposes of scaling), 18003+2154 = A 1374, 18097+5024 = HU 674, and 18103−2913 = HO 428.

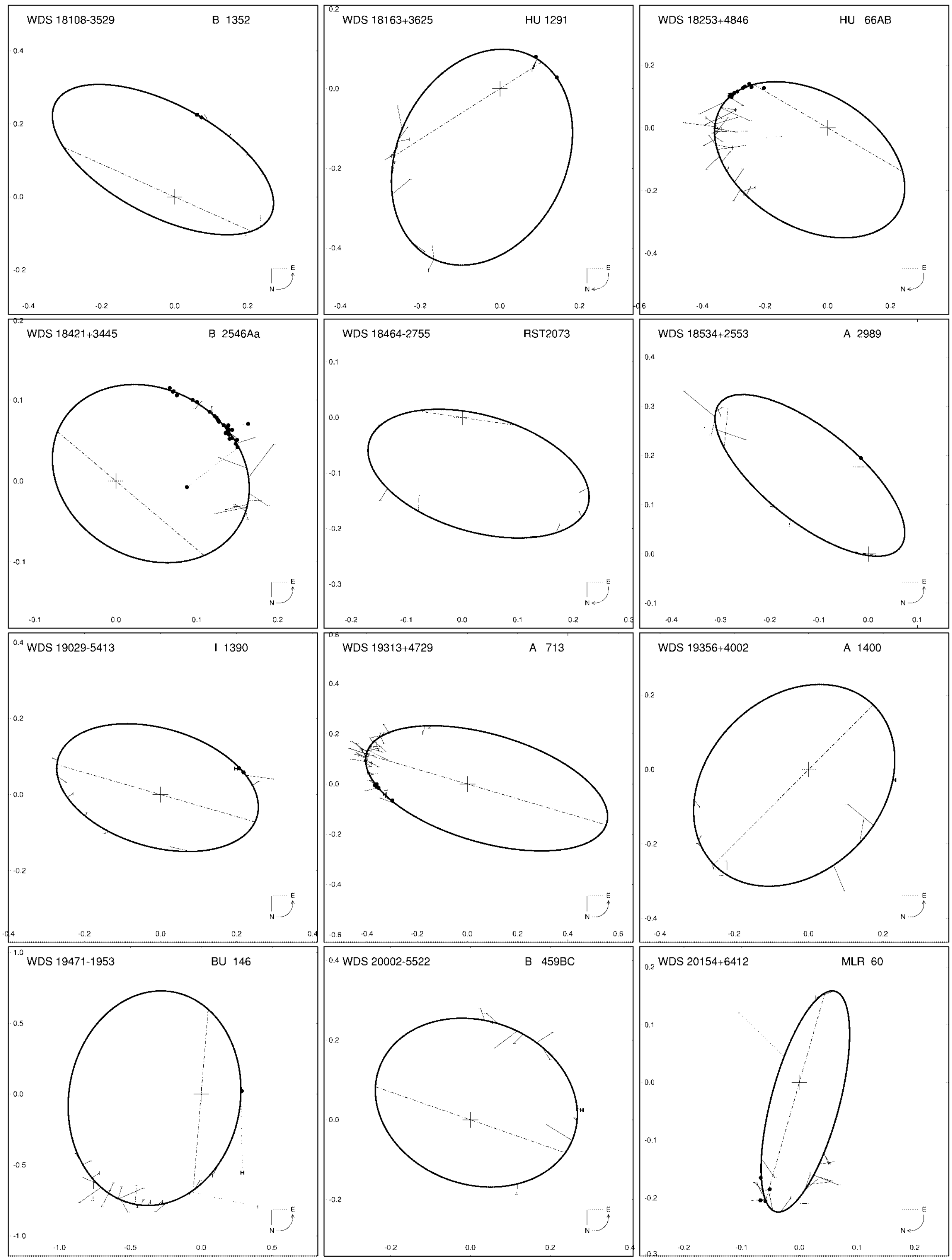

FIG. 8.—Same as Fig. 1, but for 18108−3529 = B 1352, 18163+3625 = HU 1291, 18253+4846 = HU 66 AB, 18421+3445 = B 2546 Aa, 18464−2755 = RST 2073, 18534+2553 = A 2989, 19029−5413 = I 1390, 19313+4729 = A 713, 19356+4002 = A 1400, 19471−1953 = BU 146, 20002−5522 = B 459 BC, and 20154+6412 = MLR 60.

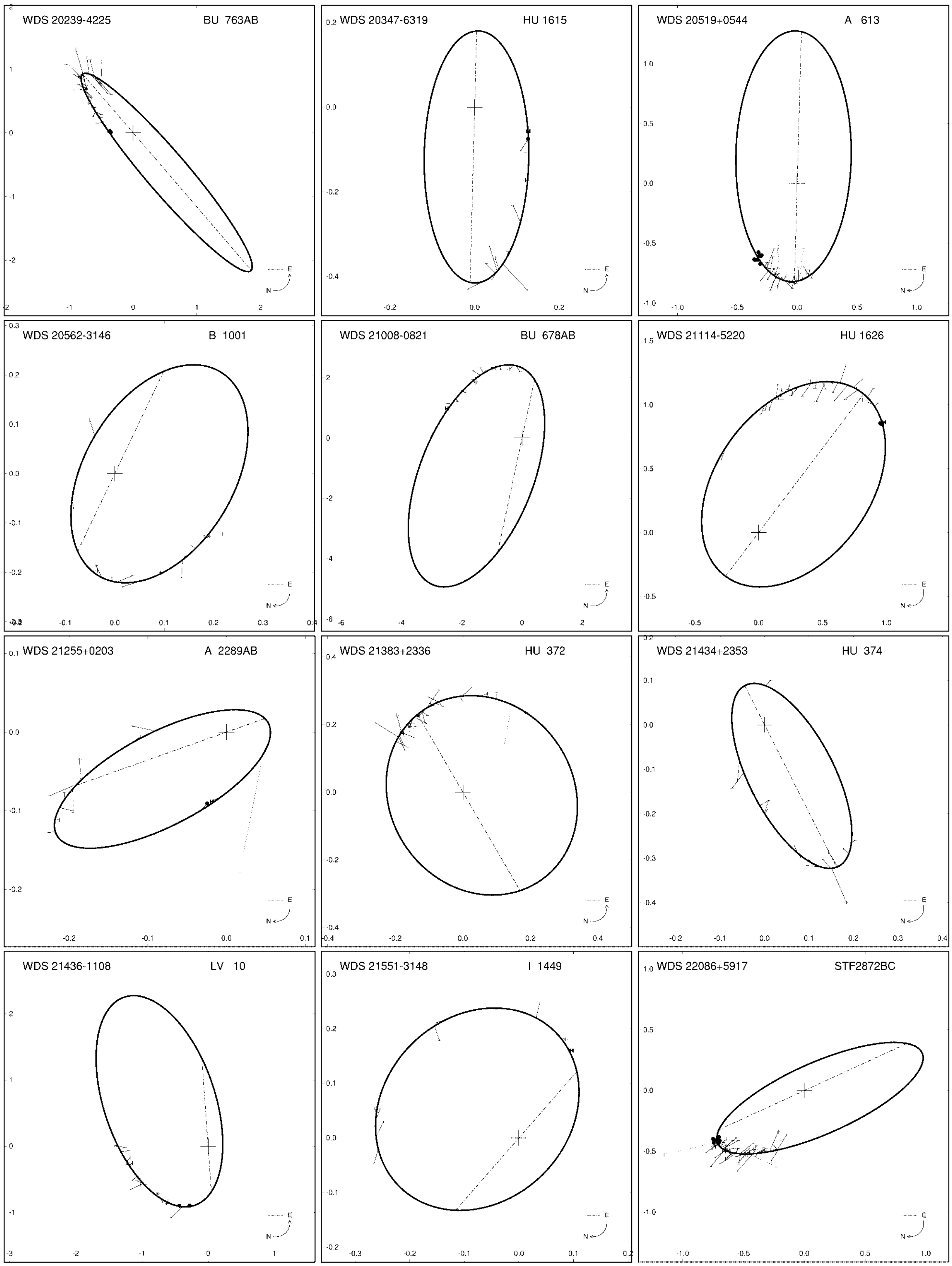

FIG. 9.—Same as Fig. 1, but for 20239−4225 = BU 763 AB, 20347−6319 = HU 1615, 20519+0544 = A 613, 20562−3146 = B 1001, 21008−0821 = BU 678 AB, 21114−5220 = HU 1626, 21255+0203 = A 2289 AB, 21383+2336 = HU 372, 21434+2353 = HU 374, 21436−1108 = LV 10, 21551−3148 = I 1449, and 22086+5917 = STF 2872 BC.

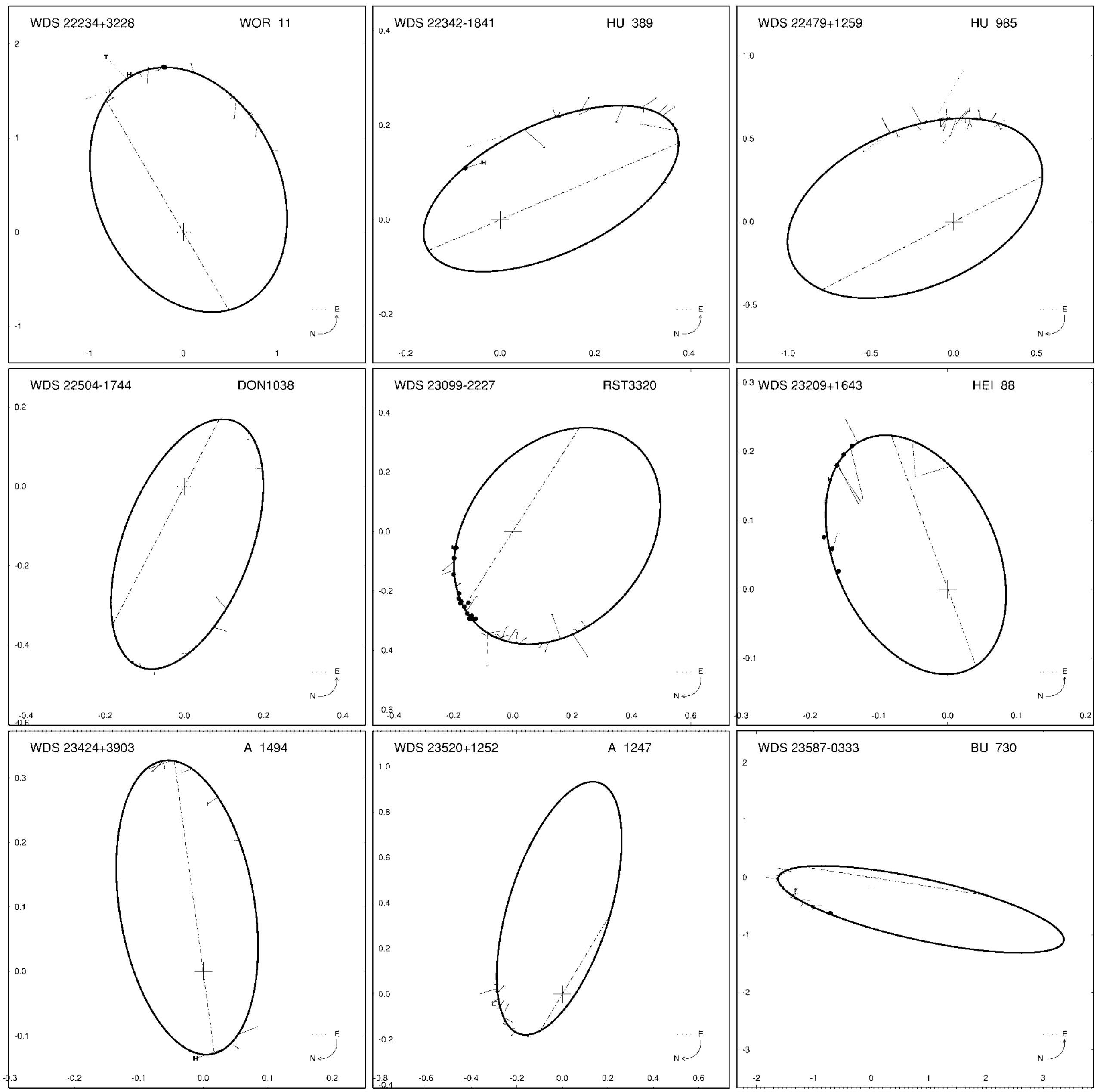

FIG. 10.—Same as Fig. 1, but for 22234+3228 = WOR 11, 22342−1841 = HU 389, 22479+1259 = HU 985, 22504−1744 = DON 1038, 23099−2227 = RST 3320, 23209+1643 = HEI 88, 23424+3903 = A 1494, 23520+1252 = A 1247, and 23587−0333 = BU 730.

columns give orbital elements, which are reported with a precision appropriate to their errors. The third column gives the orbital period (P) in years; the fourth gives the semimajor axis in arcseconds (a''); the fifth, inclination (i) in degrees; the sixth, the longitude of nodes (Ω) in degrees; the seventh, time of periastron (T_0) expressed as a fractional Besselian year; the eighth, eccentricity (e); and the ninth, the longitude of periastron (ω) in degrees. The 10th column gives the orbit grade, for which a few words of explanation are needed.

In the Fourth Catalog of Orbits of Visual Binary Stars, Worley & Heintz (1983) assigned grades between 1 ("definitive") and 5 ("indeterminate") to the published orbits. Grades in the 10th column of Table 1 were determined by the quantitative method described in Hartkopf et al. (2001). This method approximates objectively the subjective judgments of Worley & Heintz, who, as two of the three most prolific double star observers of all time, had personal experience with stars, equipment, and observers that is now impossible to duplicate.

This quantitative grading scheme is based on, among other things, the θ and phase coverage of the observations, number of revolutions traversed between the earliest and most recent observations, number of observations, and weighted rms residuals. Generally, the lower the rms residuals and the greater the coverage, the better the grade of the orbit will be. Most of the orbits published here received a grade of 4 ("preliminary") or 5 ("indeterminate") due to the lack of coverage; only the best eight were deemed to be of grade 3 ("reliable").

Ephemerides for the period 2002–2010 are presented in Table 2, the first two columns of which are identical to those

TABLE 1

ORBITAL ELEMENTS

WDS Coordinate α, δ (J. 2000.0)	Discoverer Designation	*P* (yr)	*a* (arcsec)	*i* (deg)	Ω (deg)	*T* (yr)	*e*	ω (deg)	Grade
00153+4412	A 1256 AB	330	0.29	73.8	64.3	1995.5	0.715	78	4
00345−0433	D 2 AB	1000	1.9	79.2	93	2002.5	0.948	272	4
00431+7659	HU 1012	600	1	108	40	1875	0.69	120	5
00434+4726	A 651	1500	1.96	121.3	179	1907	0.632	320	5
00520+3154	A 924	165	0.2892	140.7	48.5	1986.38	0.682	323.3	4
00533−4530	B 644	380	0.62	72.7	51	2300	0.855	111	5
00542+4318	COU 1654	90	0.15	110	91	1920	0.56	110	4
01032+2006	LDS 873	69	3.10	43	66	1996.3	0.22	77	4
01036+6341	MLR 87	110	0.39	124	128	1968	0.485	290	5
01106+5101	BU 235 Aa	280	0.74	52	122	1810	0.44	163	5
01316−5322	I 264 AB	250	1.46	107.4	141	1889.5	0.892	276.9	5
01463+4439	A 948 AB	500	0.5	67	20	1883	0.63	310	5
01500−0408	A 2602	170	0.43	79.0	3	1991	0.40	102	5
01520+1326	HU 1213	200	0.13	139	81	1830	0.72	120	5
02009−4350	I 265	640	1.07	65.2	40.2	1979.0	0.725	101.8	5
02087−1005	HU 16	500	1.3	55	10	2020	0.32	70	5
02384−0125	A 450	900	0.6	117	0	2060	0.64	250	5
02396−5425	HU 1350	250	0.79	125	8	1903	0.434	136	5
02423+4925	HU 539	175	0.222	144	19	2007.1	0.684	125	4
03184−2231	SEE 23	112.4	0.3268	65.60	89.2	1914.7	0.043	92	3
03440+5228	A 1289	300	0.3	50	150	2080	0.6	80	5
03489+1143	A 831	192	0.43	64	165	2051	0.45	30	5
04367+1930	STF 567	470	2.0	58	90	1781	0.89	81	5
04545−0314	RST 5501	147	0.35	111.9	44.7	2000.7	0.332	77	4
05043−0602	A 481	200	0.529	114.8	54	2085	0.903	279.8	4
05165−2106	DON 97	107.2	0.337	127.4	13.9	1908.4	0.392	255.9	4
05190−2159	RST 2375	97	0.373	67.2	11	2013	0.82	93.7	4
06122−3645	RST 4800	127	0.22	128	104	2040	0.35	250	5
06319−0938	A 670	131	0.336	69.0	8.4	1989.79	0.655	39	4
06594+2514	A 1061 AB	230	0.30	58	166	2005	0.30	300	5
07113−1032	A 2122	137	1.14	94.7	166	2011	0.9940	265.63	4
07486+2308	WRH 15 AB	580	0.452	117.2	55	1954	0.449	322	4
08221−4059	HJ 4087 AB	900	3	112	140	1810	0.64	110	5
09125−4032	B 1115	600	1.4	105	99	1995.8	0.8701	240	5
09264−4215	B 1122	300	0.2	50	30	2020	0.4	300	5
09387−3937	I 202	110.4	2.042	96.14	5.4	1999.3	0.913	77.38	4
09551−2632	I 843 AB	201	0.95	134	6	1862	0.48	24	5
10050−5119	HU 1594	130.3	0.361	71.8	77.3	2037	0.802	56	4
10120−2836	B 194	138	0.1969	66.4	26.8	2006.2	0.313	183	4
10275+0334	STT 218	2450	2.65	61.4	89.6	1982	0.724	49	5
10292+1009	STT 220	700	1.7	79.2	58	2500	0.36	300	5
10592−8133	I 212	1210	2.04	70.7	4.2	1972.2	0.699	219.4	5
11191−3100	I 506	580	1.9	71.3	88	2500	0.634	301	5
11265+0806	A 2575	230	0.43	67	129	2080	0.60	80	5
11279−0142	RST 4944	400	0.4	128	90	2013	0.64	250	5
11286−4508	I 885	600	1.7	100.8	8	2500	0.59	120	5
11297−0619	A 7	480	1.05	96.60	86.2	2360	0.682	114	5
11390+4109	STT 237	4000	4	122	104	1825	0.89	97	5
11518+5032	HU 730	249	0.242	130	14	2080	0.10	20	5
11585−2350	RST 3767 AB	140	0.42	60.3	62	2003	0.42	245	5
12006+6911	A 1088	134.9	0.356	75.5	29.5	2017	0.805	67.3	3
12154+4008	A 1999	630	1.79	63.7	178	1997	0.509	219	5
12268−0536	A 78	106.9	0.302	55.7	61.4	1996.44	0.862	236.3	3
12283−6146	CPO 12 A-BC	2520	5.43	143	39	1953	0.631	172.6	5
12349+2238	WRH 12	33.04	0.219	109.7	24.3	1964.62	0.898	214.5	3
13063+2044	HU 739	431	2.65	109.0	175.8	1940.3	0.454	187	5
13194−3957	RST 1712	420	0.92	136	49	1987	0.30	60	5
13325−6914	I 298	600	1.0	115	179	2030	0.346	70	5
13342−1623	RST 3844	260	0.37	119.5	65.8	1994	0.428	93	5
13379+4808	ES 608 AB	330	2.1	36	157	2047	0.61	281	5
13520−3137	BU 343	162	0.845	139.0	160.6	1998.52	0.629	241	4
14024+4620	SWI 1	460	2.5	66	22	2230	0.44	183	5
14277−4113	I 1243 AB	310	0.38	132	97	2010	0.325	200	5
14411−2237	RST 2917	140	0.32	135	120	2045	0.65	103	5

TABLE 1—*Continued*

WDS Coordinate α, δ (J. 2000.0)	Discoverer Designation	*P* (yr)	*a* (arcsec)	*i* (deg)	Ω (deg)	*T* (yr)	*e*	ω (deg)	Grade
14428+0635..........	A 1109 AB	600	3.5	83.1	88	2026.0	0.730	70	5
14464−0723..........	STF 1876 AB	600	1.3	50	120	2140	0.4	100	5
14565+0255..........	A 2172	153	0.1834	119.2	129.0	2001.1	0.241	341	3
15246−4835..........	B 1288 AB	400	0.3	70	134.7	2023	0.59	290	5
16054−1948..........	BU 947 AB	610	3.9	87.12	89.5	2480	0.9093	283	5
16054−1948..........	MCA 42 CE	28.1	0.1390	57.5	177.3	2027.8	0.30	87.2	4
16079+1425..........	A 1798	400	0.27	129	161	2027	0.464	220	5
16192+4140..........	STT 309	340	0.42	61	45	1795	0.44	67	4
16235+3321..........	VBS 26 AB	190	0.24	134.3	24	2017	0.470	61	4
16420+7353..........	MLR 198	32.1	0.173	131	39.4	1993.9	0.656	27	3
17286−2531..........	BU 129	350	0.72	62	116	2019.4	0.69	135	5
17305−1446..........	HU 177	240	0.30	140	52	1986	0.47	110	5
17368−2057..........	HU 751	201	0.365	74.6	131.0	1952.9	0.379	350.3	4
17375−3747..........	B 915 AB	168	0.28	62.2	138	2129	0.10	50	5
17436+2237..........	HU 1285	800	1.4	101.1	27	2040	0.79	250	4
17487+3536..........	HU 1182	320	0.69	123	124	2036	0.60	271	5
17586−1306..........	HU 190	460	0.82	121.4	165	1978	0.435	42	5
18003+2154..........	A 1374	240	0.74	125.4	99	1995.4	0.794	259.8	5
18097+5024..........	HU 674	800	2	102	31	2024	0.813	240	5
18103−2913..........	HO 428	800	1.4	87.0	80.2	2600	0.64	288	5
18108−3529..........	B 1352	180	0.39	66.1	66	2100	0.54	290	5
18163+3625..........	HU 1291	190.5	0.3002	149.7	122.5	1988.67	0.637	313	4
18253+4846..........	HU 66 AB	300	0.39	123	60	2022.0	0.546	270	4
18421+3445..........	B 2546 Aa	111	0.133	36	50	2030	0.38	58	4
18464−2755..........	RST 2073	63.5	0.436	104.3	81.6	1987.8	0.890	263.5	4
18534+2553..........	A 2989	180	0.74	78.7	81	1968.3	0.978	281	5
19029−5413..........	I 1390	112.2	0.274	55.3	73.8	1959.1	0.108	295	3
19313+4729..........	A 713	372	0.498	64.0	73.6	1964	0.16	189	4
19356+4002..........	A 1400	159	0.303	38.1	135	2011	0.19	3	5
19471−1953..........	BU 146	310	0.90	48	175.3	2310	0.540	276	5
20002−5522..........	B 459 BC	73.2	0.265	39.2	71	1971.39	0.222	270	4
20154+6412..........	MLR 60	43	0.21	107	164	1992.3	0.35	290	3
20239−4225..........	BU 763 AB	701	2.032	80.0	40.7	1912	0.401	177	5
20347−6319..........	HU 1615	240	0.30	63	178	2030	0.40	10	5
20519+0544..........	A 613	700	1.05	118.0	178	2610	0.227	160	5
20562−3146..........	B 1001	150	0.283	123.0	154.5	1981.4	0.547	256	5
21008−0821..........	BU 678 AB	700	4.7	64.0	168	2600	0.67	300	5
21114−5220..........	HU 1626	167	0.894	142	143	2056	0.52	178	5
21255+0203..........	A 2289 AB	140	0.163	118.4	109.5	1972.3	0.703	328	5
21383+2336..........	HU 372	390	0.31	28	30	2010	0.198	230	5
21434+2353..........	HU 374	130	0.229	120	26.8	1983.1	0.57	178	4
21436−1108..........	LV 10	610	2.3	65.3	4	2030.6	0.778	66	5
21551−3148..........	I 1449	107	0.239	135.2	139	2003.0	0.54	85.3	5
22086+5917..........	STF 2872 BC	800	1.0	107	115	2110	0.38	260	5
22234+3228..........	WOR 11	90	1.40	43	30	2021	0.37	314	5
22342−1841..........	HU 389	158	0.293	59	113.2	2012	0.44	195	4
22479+1259..........	HU 985	500	0.9	124.1	117	2080	0.416	60	5
22504−1744..........	DON 1038	90	0.364	61.2	152	1997	0.54	50	4
23099−2227..........	RST 3320	201	0.446	133.5	147	1995.1	0.462	251	4
23209+1643..........	HEI 88	38	0.187	48	20	2009	0.40	32	4
23424+3903..........	A 1494	160	0.231	120	8	1992	0.450	348	5
23520+1252..........	A 1247	900	0.8	109	149	2800	0.836	120	5
23587−0333..........	BU 730	700	4	81.0	81	2600	0.77	110	5

in Table 1. The subsequent 10 columns give the predicted position angle (θ, measured in degrees and corrected for precession) and angular separation (ρ, measured in arcseconds) for each of the epochs 2002.0, 2004.0, 2006.0, 2008.0, and 2010.0. As these orbits are preliminary only, the ephemerides given in Table 2 are expected to be both more accurate and more useful than the elements given in Table 1.

3. NOTES ON INDIVIDUAL SYSTEMS

02009−4350 = I 265: Our finding of 1979.0 as the time of periastron supports the prediction ("a close approach in the 1970's") made in the WDS.

10120−2836 = B 194: Although Hartkopf et al. (1993) predicted a time of periastron around 1989.3, we find the

TABLE 2

EPHEMERIDES

WDS Coordinate α, δ (J. 2000.0)	Discoverer Designation	2002.0 θ (deg)	2002.0 ρ (arcsec)	2004.0 θ (deg)	2004.0 ρ (arcsec)	2006.0 θ (deg)	2006.0 ρ (arcsec)	2008.0 θ (deg)	2008.0 ρ (arcsec)	2010.0 θ (deg)	2010.0 ρ (arcsec)
00153+4412	A 1256 AB	227.1	0.07	232.8	0.09	236.4	0.11	239.0	0.12	241.1	0.14
00345−0433	D 2 AB	302.0	0.04	85.6	0.10	93.0	0.19	96.2	0.25	98.3	0.29
00431+7659	HU 1012	128.5	0.47	126.8	0.48	125.1	0.48	123.4	0.49	121.8	0.49
00434+4726	A 651	148.8	0.89	147.8	0.89	146.9	0.89	146.0	0.89	145.1	0.89
00520+3154	A 924	330.5	0.18	324.2	0.19	318.8	0.20	314.0	0.21	309.7	0.23
00533−4530	B 644	342.0	0.31	343.2	0.31	344.4	0.32	345.5	0.32	346.6	0.33
00542+4318	COU 1654	87.7	0.11	82.9	0.09	75.0	0.07	56.2	0.04	348.4	0.02
01032+2006	LDS 873	198.5	2.09	212.9	2.35	224.4	2.61	234.0	2.84	242.2	3.02
01036+6341	MLR 87	50.9	0.30	45.4	0.31	40.0	0.31	34.7	0.32	29.7	0.32
01106+5101	BU 235 Aa	133.3	0.90	134.2	0.89	135.2	0.88	136.2	0.86	137.3	0.84
01316−5322	I 264 AB	35.6	0.85	34.5	0.86	33.4	0.86	32.2	0.87	31.1	0.87
01463+4439	A 948 AB	130.4	0.30	131.8	0.30	133.3	0.31	134.7	0.31	136.0	0.32
01500−0408	A 2602	178.6	0.27	180.2	0.30	181.7	0.32	183.0	0.33	184.2	0.34
01520+1326	HU 1213	93.9	0.13	91.8	0.12	89.6	0.12	87.0	0.11	84.1	0.11
02009−4350	I 265	222.5	0.47	224.1	0.49	225.6	0.50	227.0	0.52	228.4	0.53
02087−1005	HU 16	32.0	0.83	34.1	0.81	36.4	0.78	38.8	0.76	41.4	0.74
02384−0125	A 450	190.4	0.34	189.6	0.34	188.7	0.34	187.8	0.33	187.0	0.33
02396−5425	HU 1350	52.6	0.77	51.1	0.78	49.6	0.80	48.2	0.81	46.8	0.82
02423+4925	HU 539	324.4	0.08	300.2	0.06	267.6	0.06	235.7	0.06	211.5	0.08
03184−2231	SEE 23	92.0	0.32	94.7	0.32	97.6	0.31	100.8	0.29	104.2	0.28
03440+5228	A 1289	72.8	0.29	74.4	0.29	76.1	0.29	77.7	0.28	79.4	0.28
03489+1143	A 831	40.1	0.26	44.4	0.25	49.1	0.23	54.3	0.22	60.2	0.21
04367+1930	STF 567	340.8	2.04	341.1	2.04	341.5	2.04	341.8	2.04	342.2	2.04
04545−0314	RST 5501	330.1	0.09	303.2	0.09	280.4	0.11	264.8	0.13	254.6	0.16
05043−0602	A 481	294.5	0.46	293.6	0.46	292.8	0.46	292.0	0.46	291.1	0.47
05165−2106	DON 97	202.2	0.28	196.5	0.27	190.2	0.25	182.7	0.23	173.6	0.20
05190−2159	RST 2375	345.6	0.26	349.2	0.24	353.3	0.23	358.3	0.20	5.3	0.16
06122−3645	RST 4800	344.9	0.18	339.8	0.18	334.9	0.18	330.0	0.19	325.3	0.19
06319−0938	A 670	177.4	0.23	180.2	0.26	182.4	0.29	184.2	0.32	185.7	0.34
06594+2514	A 1061 AB	110.2	0.13	118.3	0.14	125.4	0.15	131.5	0.16	136.9	0.17
07113−1032	A 2122	42.1	0.09	34.7	0.09	26.4	0.08	17.0	0.08	5.0	0.06
07486+2308	WRH 15 AB	37.3	0.27	35.9	0.27	34.5	0.27	33.1	0.27	31.7	0.27
08221−4059	HJ 4087 AB	259.3	1.46	258.4	1.46	257.5	1.46	256.6	1.45	255.8	1.45
09125−4032	B 1115	112.5	0.22	107.8	0.30	105.0	0.38	103.1	0.44	101.7	0.50
09264−4215	B 1122	224.5	0.14	228.4	0.13	232.7	0.12	237.7	0.11	243.3	0.11
09387−3937	I 202	182.5	0.70	180.7	0.90	179.4	1.04	178.4	1.14	177.6	1.21
09551−2632	I 843 AB	141.5	1.00	139.5	0.97	137.4	0.95	135.1	0.92	132.8	0.89
10050−5119	HU 1594	302.8	0.23	305.5	0.22	308.5	0.20	312.0	0.19	316.1	0.18
10120−2836	B 194	199.3	0.13	203.6	0.13	207.8	0.14	212.1	0.13	216.6	0.13
10275+0334	STT 218	148.8	0.41	153.0	0.40	157.3	0.39	161.8	0.39	166.3	0.39
10292+1009	STT 220	102.3	0.54	104.1	0.52	105.9	0.51	107.8	0.50	109.8	0.49
10592−8133	I 212	299.9	0.28	306.8	0.30	312.7	0.33	317.6	0.36	321.8	0.39
11191−3100	I 506	160.4	0.79	162.2	0.79	164.1	0.79	166.0	0.79	167.8	0.79
11265+0806	A 2575	48.5	0.25	51.4	0.25	54.3	0.25	57.1	0.25	60.0	0.25
11279−0142	RST 4944	263.5	0.17	258.0	0.16	251.5	0.14	243.5	0.13	233.5	0.11
11286−4508	I 885	153.4	0.61	152.1	0.60	150.7	0.58	149.3	0.57	147.8	0.56
11297−0619	A 7	186.8	0.17	182.2	0.17	177.4	0.17	172.8	0.17	168.2	0.18
11390+4109	STT 237	245.8	1.97	245.5	1.98	245.3	1.99	245.0	2.00	244.8	2.01
11518+5032	HU 730	123.5	0.17	119.7	0.17	115.8	0.16	111.7	0.16	107.6	0.16
11585−2350	RST 3767 AB	283.0	0.16	301.8	0.13	326.4	0.12	351.4	0.13	10.8	0.16
12006+6911	A 1088	347.6	0.12	354.0	0.13	0.1	0.13	5.9	0.13	11.5	0.13
12154+4008	A 1999	25.0	0.65	28.4	0.62	32.2	0.59	36.4	0.56	41.1	0.53
12268−0536	A 78	66.0	0.18	70.4	0.22	73.6	0.25	76.1	0.28	78.3	0.30
12283−6146	CPO 12 A-BC	194.2	2.08	193.0	2.08	191.8	2.09	190.6	2.09	189.4	2.10
12349+2238	WRH 12	20.3	0.24	18.1	0.29	16.5	0.32	15.1	0.34	13.8	0.36
13063+2044	HU 739	215.1	1.14	212.6	1.21	210.4	1.28	208.4	1.34	206.6	1.41
13194−3957	RST 1712	332.0	0.48	327.7	0.48	323.4	0.48	319.2	0.48	315.0	0.49
13325−6914	I 298	164.0	0.61	162.6	0.59	161.2	0.58	159.7	0.56	158.1	0.54
13342−1623	RST 3844	283.7	0.15	276.8	0.17	271.1	0.18	266.5	0.20	262.5	0.22
13379+4808	ES 608 AB	319.8	1.93	321.5	1.89	323.4	1.84	325.2	1.79	327.3	1.74
13520−3137	BU 343	235.0	0.26	212.6	0.32	197.5	0.39	186.9	0.46	179.0	0.52
14024+4620	SWI 1	24.0	3.67	24.2	3.66	24.5	3.66	24.8	3.65	25.1	3.65

TABLE 2—*Continued*

WDS Coordinate α, δ (J. 2000.0)	Discoverer Designation	2002.0 θ (deg)	2002.0 ρ (arcsec)	2004.0 θ (deg)	2004.0 ρ (arcsec)	2006.0 θ (deg)	2006.0 ρ (arcsec)	2008.0 θ (deg)	2008.0 ρ (arcsec)	2010.0 θ (deg)	2010.0 ρ (arcsec)
14277−4113	I 1243 AB	283.3	0.26	280.2	0.26	277.0	0.26	273.9	0.26	270.6	0.26
14411−2237	RST 2917	169.6	0.38	167.6	0.38	165.6	0.37	163.6	0.37	161.4	0.36
14428+0635	A 1109 AB	84.5	1.51	85.0	1.48	85.6	1.44	86.2	1.39	86.9	1.33
14464−0723	STF 1876 AB	108.5	1.28	109.2	1.27	109.8	1.27	110.5	1.26	111.2	1.26
14565+0255	A 2172	136.8	0.14	132.8	0.14	129.0	0.14	125.2	0.14	121.4	0.14
15246−4835	B 1288 AB	335.7	0.12	339.1	0.11	343.2	0.10	348.5	0.09	355.3	0.08
16054−1948	BU 947 AB	164.9	0.30	169.1	0.30	173.3	0.30	177.6	0.30	181.7	0.30
16054−1948	MCA 42 CE	334.6	0.09	355.7	0.13	10.0	0.14	23.8	0.13	39.9	0.12
16079+1425	A 1798	359.6	0.17	356.6	0.17	353.5	0.16	350.5	0.16	347.3	0.16
16192+4140	STT 309	301.0	0.29	303.0	0.28	304.9	0.28	306.9	0.28	308.9	0.28
16235+3321	VBS 26 AB	32.4	0.16	27.3	0.16	21.6	0.15	15.4	0.14	8.4	0.13
16420+7353	MLR 198	40.0	0.23	34.6	0.26	29.8	0.27	25.3	0.27	20.8	0.27
17286−2531	BU 129	140.5	0.29	145.2	0.26	151.5	0.22	160.5	0.18	173.7	0.15
17305−1446	HU 177	232.4	0.20	227.7	0.20	223.3	0.21	219.2	0.22	215.3	0.22
17368−2057	HU 751	285.2	0.22	287.5	0.24	289.4	0.25	291.2	0.27	292.6	0.29
17375−3747	B 915 AB	300.4	0.24	303.0	0.25	305.3	0.26	307.5	0.27	309.5	0.28
17436+2237	HU 1285	216.9	0.55	216.3	0.55	215.6	0.54	214.9	0.54	214.2	0.53
17487+3536	HU 1182	314.6	0.53	312.9	0.52	311.2	0.51	309.3	0.49	307.3	0.48
17586−1306	HU 190	74.3	0.27	67.6	0.28	61.4	0.28	55.5	0.30	50.1	0.31
18003+2154	A 1374	104.4	0.27	98.0	0.33	93.2	0.37	89.4	0.41	86.2	0.45
18097+5024	HU 674	218.4	0.68	217.3	0.66	216.1	0.64	214.9	0.62	213.6	0.59
18103−2913	HO 428	90.5	0.49	90.8	0.48	91.2	0.47	91.5	0.46	91.8	0.45
18108−3529	B 1352	182.7	0.26	185.5	0.27	188.2	0.28	190.8	0.28	193.3	0.29
18163+3625	HU 1291	77.9	0.18	71.1	0.19	65.1	0.20	59.7	0.21	54.9	0.22
18253+4846	HU 66 AB	232.9	0.24	229.8	0.23	226.4	0.21	222.3	0.20	217.5	0.18
18421+3445	B 2546 Aa	160.9	0.12	166.4	0.12	172.2	0.12	178.3	0.12	184.5	0.12
18464−2755	RST 2073	49.3	0.28	46.2	0.28	42.9	0.27	39.6	0.27	36.2	0.26
18534+2553	A 2989	191.0	0.22	192.8	0.23	194.4	0.24	195.8	0.25	197.2	0.26
19029−5413	I 1390	146.8	0.17	156.0	0.17	165.3	0.17	174.5	0.17	183.2	0.18
19313+4729	A 713	288.4	0.28	291.1	0.28	293.9	0.27	296.9	0.26	300.1	0.25
19356+4002	A 1400	114.3	0.24	119.8	0.24	125.1	0.24	130.5	0.24	135.8	0.24
19471−1953	BU 146	145.4	0.40	151.4	0.43	156.6	0.46	161.2	0.50	165.3	0.52
20002−5522	B 459 BC	136.5	0.26	144.6	0.25	152.8	0.25	161.1	0.25	169.3	0.25
20154+6412	MLR 60	143.0	0.14	131.2	0.12	112.4	0.09	83.5	0.08	52.2	0.08
20239−4225	BU 763 AB	301.7	0.30	309.1	0.30	316.4	0.30	323.5	0.31	330.0	0.33
20347−6319	HU 1615	103.1	0.12	111.0	0.12	118.7	0.12	126.0	0.12	132.7	0.13
20519+0544	A 613	328.5	0.67	327.3	0.67	326.1	0.66	324.9	0.65	323.7	0.64
20562−3146	B 1001	148.9	0.25	146.3	0.26	143.8	0.27	141.5	0.28	139.4	0.29
21008−0821	BU 678 AB	255.8	2.73	256.8	2.75	257.8	2.76	258.7	2.78	259.7	2.79
21114−5220	HU 1626	123.8	1.19	122.1	1.17	120.4	1.14	118.6	1.12	116.7	1.09
21255+0203	A 289 AB	332.6	0.13	330.0	0.14	327.7	0.15	325.6	0.15	323.8	0.16
21383+2336	HU 372	244.9	0.24	247.6	0.24	250.4	0.24	253.1	0.23	256.0	0.23
21434+2353	HU 374	70.6	0.14	65.2	0.16	60.9	0.18	57.3	0.19	54.3	0.21
21436−1108	LV 10	343.3	0.95	345.1	0.94	347.0	0.92	349.0	0.90	351.1	0.87
21551−3148	I 1449	72.9	0.08	35.6	0.08	4.7	0.10	345.0	0.12	332.0	0.14
22086+5917	STF 2872 BC	299.3	0.82	298.9	0.82	298.6	0.82	298.3	0.82	297.9	0.81
22234+3228	WOR 11	221.4	1.44	226.8	1.35	233.1	1.24	240.7	1.12	250.2	1.00
22342−1841	HU 389	266.2	0.15	273.5	0.16	280.4	0.16	287.1	0.17	293.7	0.16
22479+1259	HU 985	144.6	0.66	143.3	0.66	142.1	0.67	140.8	0.67	139.6	0.67
22504−1744	DON 1038	288.0	0.13	305.8	0.19	315.3	0.24	321.4	0.29	325.9	0.33
23099−2227	RST 3320	213.7	0.18	201.9	0.20	192.1	0.22	184.1	0.24	177.4	0.27
23209+1643	HEI 88	302.1	0.13	328.6	0.12	355.5	0.12	22.9	0.12	59.4	0.09
23424+3903	A 1494	338.5	0.12	330.0	0.11	320.7	0.10	310.5	0.10	299.7	0.10
23520+1252	A 1247	253.0	0.30	251.9	0.30	250.8	0.30	249.7	0.31	248.6	0.31
23587−0333	BU 730	317.1	0.92	318.8	0.91	320.5	0.90	322.2	0.89	324.0	0.88

time of periastron to be 2006.2. The discrepancy may be explained by three measures not published at the time of the 1993 paper.

16054−1948 = BU 947 AB and MCA 42 CE: Orbits for two component pairs of this complex star system were calculated independently of one another. A complex, multi-body solution was not attempted.

18253+4846 = HU 66 AB: Van Biesbroeck (1954) was unable to resolve this system in 1943, 1944, or 1945 on the 82 inch (2.1 m) telescope at the McDonald Observatory.

However, since he resolved the system successfully in 1946 with the same telescope, and in 1940 with a smaller (40 inch) telescope, the nonresolution is probably due to bad seeing or identification error.

4. CONCLUSIONS

While the orbits presented in Table 1 can hardly be considered reliable over the course of even a single revolution, the ephemerides in Table 2 should be quite adequate for the next decade. Indeed, it might be said that the greatest use of the elements from Table 1 is for the prediction of ρ and θ for epochs not given in Table 2. It is hoped that inclusion of these objects in dedicated observational programs may ascertain the veracity of these orbital elements.

Thanks are provided to the US Naval Observatory for their continued support of the double star program, and to the Science and Engineering Apprenticeship Program (SEAP-CQL), a joint effort by the Department of Defense and George Washington University, which also sponsored this research. This research has made use of the SIMBAD database, maintained and operated at CDS, Strasbourg, France.

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