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SPECKLE INTERFEROMETRY AT SOAR IN 2010 AND 2011: MEASURES, ORBITS, AND RECTILINEAR FITS*

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ABSTRACT

We report on the results of speckle observations at the 4.1 m SOAR telescope in 2010 and 2011. A total of 639 objects were observed. We give 562 measurements of 418 resolved binaries, including 21 pairs resolved for the first time, and upper detection limits for 221 unresolved stars. New orbital elements have been determined for 42 physical pairs, of which 22 are first-time calculations; the rest are corrections, sometimes substantial. Linear elements are calculated for nine apparently optical doubles. We comment on new pairs, new orbital solutions, and other remarkable objects.

Key words: binaries: general – techniques: interferometric

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

1. INTRODUCTION

Binary stars are one of the foundations of astronomy. Like any "infrastructure," they tend to be neglected in favor of more fashionable topics. Maintaining this solid foundation is nevertheless essential. This paper aims mainly at determination and improvement of visual binary star orbits.

Orbits are not only a source of direct mass determinations, but much more. Knowledge of visual orbital elements is needed to study dynamics of multiple systems with three or more bodies (including planets in binaries), as a tracer of star formation (statistics of periods, mass ratios, and eccentricities), and for accurate astrometry. The duration of past and future astrometric space missions is too short to disentangle slow orbital motion from parallax, but this is possible when long-term ground-based measurements of binaries are available. Today's observations cannot be repeated later, even with improved future capabilities. Of the 113,366 pairs in the Washington Double Star Catalog (WDS) (Mason et al. 2001), only 2158 (or 1.9%) have orbital determinations of any quality. Of these, only 310 have orbits graded as either "definitive" or "good" in the Sixth Catalog of Orbits of Visual Binary Stars (Hartkopf et al. 2001), while 60% of cataloged orbits (excluding astrometric solutions) are considered either "preliminary" or "indeterminate." Southern pairs are particularly underrepresented in the catalog, and those with orbits are in general of poorer quality, due to a historic lack of observations.

Speckle interferometry at 4 m telescopes is an almost unique source of modern binary star measurements with high precision, the contribution from adaptive optics (AO) or long baseline interferometry being small in number. Speckle interferometry runs at the Blanco and SOAR telescopes in 2008–2009 (Tokovinin et al. 2010c, hereafter TMH10) produced a rich harvest of data (1898 measurements of 1189 pairs) and discoveries (48 newly resolved pairs). Over 100 new southern orbits have been calculated since 2009 (cf. Hartkopf & Mason 2010; Mason et al. 2010; Mason & Hartkopf 2011a, 2011b), due in large measure to efforts such as these. Continuing monitoring of orbital motion is needed for further progress, however. Many close pairs resolved recently have periods shorter than 20 years and need frequent revisits to provide adequate phase coverage.

Apart from visual binaries with orbital motion, we included in the program some multiple stars, nearby astrometric binaries detected by *Hipparcos* but never resolved, and bright Herbig Ae/Be (HAeBe) stars—a project by J. Patience, to search for companions.

We used the same speckle camera and data processing as in TMH10; the differences and calibrations are presented in Section 2. Section 3 contains the results: data tables and new orbitals and linear fits. Comments on individual systems are given in Section 4.

2. OBSERVATIONS AND DATA ANALYSIS

2.1. Instrument, Observing Runs, and Procedure

The observations reported here were obtained with the *high-resolution camera* (HRCam)—a fast imager designed to work at the SOAR telescope, either with the SOAR Adaptive Module (SAM) or as a stand-alone instrument. The HRCam is described by Tokovinin & Cantarutti (2008). The previous series of measurements reported in TMH10 used HRCam installed at the infrared port of SOAR. In 2009, the HRCam worked with SAM during its first-light tests and produced some double-star measures (Tokovinin et al. 2010a, hereafter SAM10). It was also installed on SAM for the observations reported in this paper. A description of the instrument can be found in the above papers. The only difference here is the replacement of the Strömgren filter *y* by a more efficient commercial filter[3] (central wavelength 534 nm, bandwidth 22 nm) and the use of an atmospheric dispersion corrector (ADC). This new feature made the dispersion modeling in data reduction unnecessary; it is applied only to the data taken without the ADC.

This program was allocated four nights at SOAR which were split into two runs, 2010 December 18–19 and 2011

* Based on observations at the SOAR telescope, NOAO proposal 2010B-0096. SOAR is operated by AURA, Inc., under contract with the National Science Foundation.

[3] Part number NT67-032 from Edmund Optics.

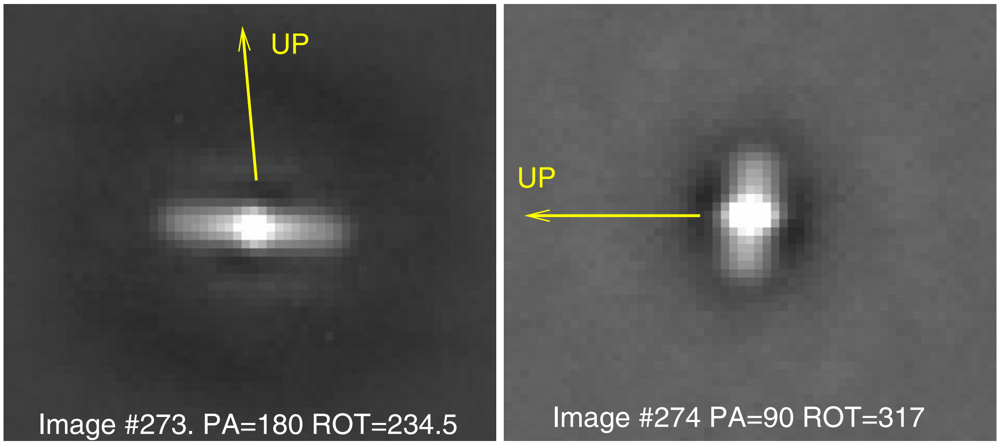

Figure 1. Autocorrelations of two data cubes recorded sequentially in 2010 November, with different orientations of the instrument and 20 ms exposures, zenith distances 48° and 41°. The 50 Hz vibrations cause elongation of the ACF preferentially (but not exactly) in the horizontal direction. The ADC was used here.

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

Table 1
Observing Runs

Dates	Dichroic, Mode
2010 Nov 20–23	VIS+AO
2010 Dec 18–19	UV, classical
2010 Dec 20–24	VIS+AO
2011 Jan 13–14	UV, classical
2011 Apr 15–18	UV, classical

January 13–14. During these runs, all stellar light was directed to the speckle camera by the UV dichroic inside SAM, leaving no signal for adaptive turbulence compensation. The deformable mirror was maintained "flat" by an open-loop control. The instrument was not dismounted during the above period, so the same calibration was used for both.

This work also includes double-star measures done occasionally during SAM commissioning runs in 2010 and 2011. In this configuration, as in SAM10, the camera received only ∼15% of the light reflected by the VIS (visual) dichroic in SAM, the rest being used for wave front sensing. Most of the time the turbulence was partially compensated by the AO, improving the signal and partially offsetting the loss of light. SAM was removed from the telescope in February and installed again with the UV dichroic. The position angle of the camera changed slightly as a result.

The observing runs are listed in Table 1. The seeing during our regular science runs in December and January was good (the width of re-centered images is from 0″.69 to 0″.94 in 50% of cases, the median image quality is 0″.8). All four allocated nights were clear. On the other hand, additional speckle observations during three SAM commissioning runs were obtained sometimes under marginal conditions, when the AO system could not operate (poor seeing and/or transparent cirrus).

The observing procedure is the same as the one described in TMH10, apart from the turbulence compensation during SAM commissioning and the use of the ADC. Note that in most cases the field of view was 3″, so companions with separations larger than ∼1″.5 remain undetected unless the image was re-centered on the system.

The availability of the SAM wave front sensor has enabled us to better understand the instrument. We found that the light beam at the SOAR Nasmyth foci vibrates with a frequency of 50 Hz and variable amplitude, reaching in the worst case 30 mas rms (∼90 mas peak to valley). The typical exposure time of 20 ms samples exactly one period of this vibration, which is manifested by speckle elongation. A sinusoidal vibration can mimic a binary star (we even see a few fringes in the power spectrum), but in most cases the vibration amplitude was not stationary during acquisition of the data cubes, causing a disk-like feature in the autocorrelation functions (ACFs). Vibrations occur preferentially in the azimuthal direction (Figure 1). Shortening the exposure time to 5 ms has greatly reduced the elongation, at the expense of sensitivity. We used the 5 ms exposure time whenever possible. Comparison of the ACFs with 20 ms and 5 ms exposures of the same target gives a clear indication of the vibration impact; see also SAM10.

2.2. Calibration

There are two guide probes on translation stages in the focal plane of SAM (before re-imaging by the AO and HRCam). Each probe holds a point light source. By moving the probe in X or Y and taking images in the HRCam, we can accurately measure the pixel scale (in millimeters at the SOAR focus) and detector orientation (in the SAM coordinate system). These measurements were done twice: on 2010 November 18 and on December 19. The two results are practically identical: pixel size 5.008 μm and detector rotation 1°.69 ± 0°.01 CCW (counter-clockwise). With a nominal SAM position angle of 0° on the sky, the detector X-axis points to the west and Y-axis to the north.

With the nominal SOAR effective focal length of 68.175 m the pixel scale would be 15.15 mas. We use here the pixel scale of 15.23 mas as in TMH10 (the difference is +0.52%). Note that the present system contains two deformable mirrors, the SOAR thin primary mirror controlled by active optics and the SAM deformable mirror controlled by the wave front sensor or in open loop. Changing the curvature of either mirror would affect the pixel scale. It is not known at present whether the SOAR effective focal length is stable at the sub-percent level. The SAM optical magnification can be monitored by the internal calibration described above. Although we cannot give formal errors, the scale is correct to better than 1%.

As to the position angle, we rely here on the mechanical calibration and add an offset of −1°.7 to the angles measured on the detector. This is equivalent to a reasonable assumption that the SAM mechanical fabrication is accurate to a fraction of a degree. During SAM alignment in November, pupil images were

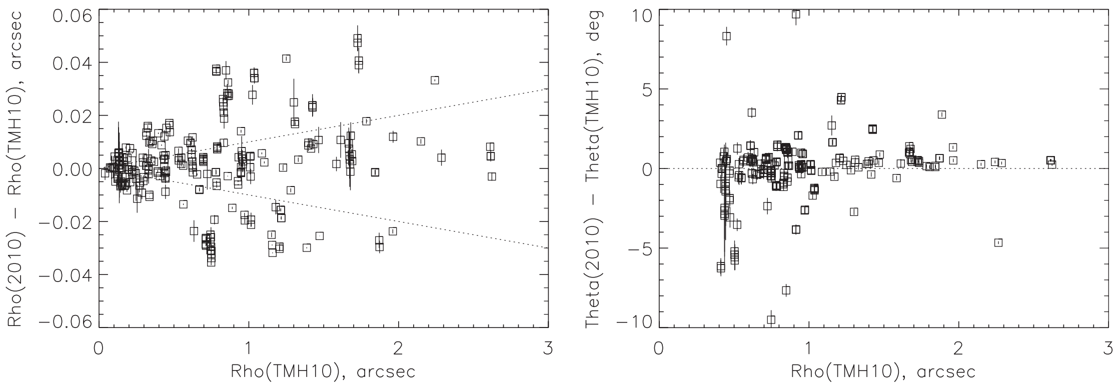

Figure 2. Inter-comparison of measures here and in TMH10 for 259 common pairs. Left: separation; right: position angle. The dotted lines show ±1% deviations in the pixel scale. The estimated measurement errors are shown by the vertical lines.

Table 2
Resolved Pairs

WDS α,δ (2000)	Discoverer Designation	HIP, HD, DM	BY (−2000)	Filt	N_c	θ (°)	$\rho\sigma_\theta$ (mas)	ρ ($''$)	σ_ρ (mas)	Δm (mag)	$O-C$ (°)	$O-C$ ($''$)	Reference	Note
00098−3347	SEE 3	HIP 794	10.9682	I	2	118.2	0.2	0.8195	0.3	1.1	0.6	0.006	Hartkopf & Mason (2010)	
00143−2732	HDS 33	HIP 1144	11.0366	y	2	152.1	0.5	0.1435	0.4	1.1	10.2	−0.056	Cvetkovic (2010)	
00203−3246	B 1025	HIP 1625	10.9682	y	2	186.2	0.5	0.5908	0.3	2.0	−0.1	−0.000	Table 4	
			10.9682	I	2	186.1	0.4	0.5906	0.4	1.4:	−0.2	−0.000	Table 4	
00219−2300	RST 5493 BC	HIP 1732	11.0366	I	2	89.7	0.1	0.1978	0.4	0.3				
			11.0366	y	2	89.8	0.1	0.1980	0.1	0.6:				
00261−1123	YR 4	HIP 2066	11.0393	I	2	183.9	2.0	0.3862	0.7	2.8				
00271−0753	A 431	HIP 2143	11.0393	y	1	354.9	0.1	0.1942	0.1	0.4:	−2.5	−0.009	Scardia (1981)	
00284−2020	B 1909	HIP 2237	10.8942	y	4	337.0	0.6	0.0914	0.8	0.7	6.0	−0.025	Hartkopf & Mason (2010)	
			10.8942	I	3	336.8	0.7	0.0917	0.7	0.3:	5.8	−0.025	Hartkopf & Mason (2010)	

(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.)

obtained in HRCam with a special lens. The orientation of the secondary-mirror spider on these images gives an angular offset of −1°.90 ± 0°.05, in close agreement with the previous result. In the April run the mechanical offset in angle was determined as −4°.2. Note that the angle calibration is affected by the accuracy of the SOAR Nasmyth rotator which, in turn, depends on the telescope pointing model. The SOAR pointing model was in need of an update during these observations.

Figure 2 compares present data with those of TMH10. The scatter is mostly caused by the orbital motion of binaries between these two data sets. The pixel scale in these two data sets is consistent to better than 0.5% while an angular offset of −2°.2 (instead of −1°.7) would give a better agreement on wide binaries, eliminating a positive difference of 0°.5.

3. RESULTS

3.1. Data Tables

Table 2 lists 562 measurements of 418 resolved known and new binary stars and subsystems. Its columns contain (1) the WDS designation, (2) the "discoverer designation" as adopted in the WDS, (3) an alternative name, mostly from the *Hipparcos* catalog, (4) Besselian epoch of observation, (5) filter, (6) number of individual data cubes, (7 and 8) position angle θ in degrees and internal measurement error in tangential direction $\rho\sigma_\theta$ in mas, (9 and 10) separation ρ in arcseconds and its internal error σ_ρ in mas, and (11) magnitude difference Δm. An asterisk follows the value if Δm and the true quadrant are determined from the resolved photometry; a colon indicates that the data are noisy and Δm is likely overestimated. We decided not to mark with colons the Δm values of wide pairs overestimated only due to anisoplanatism (when no resolved photometry is available), to avoid confusion with the low signal-to-noise ratio cases. Note that in the cases of multiple stars, the positions and photometry refer to the pairings between individual stars, not with photocenters of subsystems.

For stars with known orbital elements, Columns 12–14 of Table 2 list the residuals to the ephemeris position and the reference to the orbit from the *Sixth Orbit Catalog* (Hartkopf et al. 2001). In those cases where multiple orbits for the same system are present in the catalog, the orbit with the smallest residuals is selected. Residuals to linear fits from the *Rectilinear Elements Catalog* (Hartkopf et al. 2011) are listed in a similar manner. An asterisk in the final column indicates that a note concerning this system may be found in Section 4 below.

Table 3 contains the data on 221 unresolved stars, some of which are listed as binaries in the WDS or resolved here in other runs or filters. Columns 1 through 6 are the same as in Table 2 (although Column 2 also includes Bayer designations, HD numbers, or other names for objects without discoverer designations). Columns 7 and 8 give the 5σ detection limits Δm_5 at 0″.15 and 1″ separations determined by the procedure described in TMH10. When two or more data cubes are processed, the best detection limits are listed. Noisy data are marked by colons to indicate that the actual detection limits are smaller. For multiple stars where some companions are resolved, the detection limits for unresolved companions in Table 3 mean magnitude difference relative to the primary. As in Table 2, the final column indicates a note to the system. In general the resolution limit is 30 mas for observations obtained with the y filter and 44 mas for those made in I. These limits are

Table 3
Single/Unresolved Objects

WDS or α,δ (2000)	GJ, NLTT, HR, HD, DD, etc.	HIP	Date (−2000.)	Filt	N_c	Δm_5 (0″.15)	Δm_5 (1″)	Note
00146−1856	7 Cet	1170	10.8886	...	2	3.92	5.86	
00196−0713	HD 1539	1573	11.0393	y	2	4.91	5.75	
			11.0393	I	1	4.08	5.63	
00219−2300	HJ 1957 A	1732	11.0366	y	2	4.45	6.28	
			11.0366	I	1	3.48	5.63	
00262−4341	κ Phe	2072	10.9681	y	2	4.97	7.18	
00374−3717	I 705	2944	10.9681	I	2	3.84	5.69	
01144−0755	WSI 70 Aa,Ab	5799	11.0365	y	2	4.58	6.85	
01150−6007	FIN 79	5844	10.9653	y	1	3.22	3.62	
			10.9653	I	2	3.24:	3.79:	

(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.)

approximate because of vibrations and are worse for the faint stars marked by colons in the table.

3.2. New Orbital and Linear Elements

New orbital solutions were attempted for all systems without previously published elements whose measures indicated significant orbital motion, as well as those systems whose recent measures showed considerable residuals from published elements. The "grid search" method used for these calculations is described by Hartkopf et al. (1989), with the weighting system for individual observations described by Hartkopf et al. (2001). A total of 42 systems yielded new solutions which were deemed of sufficient quality for publication. Elements for these systems are given in Table 4, where Columns 1 and 2 give the WDS and discoverer designations and Columns 3–9 list the seven Campbell elements: P (period, in years), a (semimajor axis, in arcseconds), i (inclination, in degrees), Ω (longitude of node, equinox 2000, in degrees), T_0 (epoch of periastron passage, in fractional Besselian year), e (eccentricity), and ω (longitude of periastron, in degrees). Column 10 gives a rough grade for each orbit (where 1 = "definitive" and 5 = "indeterminate"), as described by Hartkopf et al. (2001) and based on similar grading schemes used in earlier orbit catalogs. Formal errors are listed below each element unless the solutions received grades of 4 or 5; formal errors for these preliminary solutions were considered to be of little meaning. Column 11 gives a reference for the previous "preferred" published orbit currently listed in the *Sixth Orbit Catalog*; an asterisk in Column 12 indicates that a note for this system may be found in Section 4 below.

Figure 3 shows the new orbital solutions, plotted with all published data in the WDS database. Micrometric observations are indicated by plus signs, CCD measures by triangles, interferometric measures by filled circles or (for the new SOAR measures) filled stars, and *Hipparcos* and *Tycho* measures by the letters "H" or "T." "$O - C$" lines connect each measure to its predicted position along the new orbit (shown as a thick solid line). A dotted $O - C$ line indicates a measure given zero weight in the final orbit solutions. 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. Previously published orbits are shown as dashed ellipses; references to each of the published orbits are given in the Column 11 of Table 4.

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

The apparently linear relative motions of nine systems 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 6, 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). Finally, an asterisk in Column 10 indicates a note for this system in the text. See Hartkopf et al. (2011) for a description of all terms.

Table 7 gives linear ephemerides for each pair over the years 2012 through 2020; the format is identical to that in Table 5.

3.3. Newly Resolved Pairs

A total of 21 pairs are resolved here for the first time; these are denoted in Table 2 as TOK 181 through TOK 201. For the most part they are solar-type dwarfs within 70 pc suspected to be binary by *Hipparcos* astrometry (Makarov & Kaplan 2005) and/or variable radial velocity (Nordström el al. 2004). Resolution allows us to estimate mass ratio from photometry and to evaluate order-of-magnitude periods from projected separations. A large fraction of such stars was found to be unresolved here. This adds useful constraints on the companion parameters which are either too close or too faint.

4. NOTES ON INDIVIDUAL OBJECTS

Information on other companions and subsystems in the following notes is mostly taken from The Multiple Star Catalog (Tokovinin 1997), referenced as MSC. RV stands for radial velocity, SB for spectroscopic binary, and CPM for common proper motion.

01128−3751 = HIP 5661 = AI Scl = TOK 181. A new binary HAeBe star with a very faint companion, $\Delta I = 6.2$ mag at 1″.4. The measure in the y filter is below the formal detection limit, but it is assisted by the I-filter data.

01166 + 1831 = HIP 5952 = HDS 169. The primary is a metal-poor G5 dwarf; based on magnitude difference, the secondary is late-K or early-M. A is a 274 day SB1 (MSC). A very preliminary orbit (period 144 years) yields a mass sum too high for these spectral types, however.

Table 4
New Orbital Elements

WDS (Figure)	Discoverer Designation	P (yr)	a ($''$)	i (°)	Ω (°)	T_o (yr)	e	ω (°)	Gr	Published Orbit Reference	Note
00203−3246	B 1025	126.11	0.609	109.1	167.2	1920.97	0.544	283.5	4		
02057−2423	I 454 AB	211.63	1.010	75.7	326.2	2038.64	0.587	328.1	5		*
02225−2349	LAF 27	26.50	0.493	44.8	131.6	2015.69	0.200	95.5	4	Gontcharov & Kiyaeva (2002)	*
02415−7128	B 1923	101.05	0.525	116.1	222.8	2011.50	0.379	252.9	4		*
02442−2530	FIN 379 Aa,Ab	6.7039	0.0996	42.37	4.6	2008.843	0.5066	8.9	2	Honig & Tscharnuter (2005)	*
		±0.0050	±0.0006	±0.98	±2.2	±0.014	±0.0064	±3.3			
02539−4436	I 1480	52.45	0.270	38.9	315.2	1954.42	0.825	352.0	4		*
03544−4021	FIN 344 AB	14.11	0.0617	34.0	236.7	2008.107	0.605	60.1	2		*
		±0.13	±0.0010	±2.8	±5.0	±0.047	±0.019	±5.2			
04008+0505	A 1937	41.6	0.097	36.	169.	2013.2	0.74	51.	3	Brendley & Hartkopf (2006)	
		±1.9	±0.017	±19.	±57.	±1.9	±0.14	±54.			
04205−0119	RST 4769	77.57	0.2921	97.34	198.28	1997.21	0.3311	23.5	3	Heintz (1997)	*
		±0.39	±0.0031	±0.52	±0.48	±0.44	±0.0070	±2.7			
04536+2522	CHR 127 AB	59.20	0.170	57.0	151.5	1983.16	0.539	34.9	4		*
05103−0736	A 484	37.62	0.2079	101.7	124.76	1983.7	0.007	270.	3	Heintz (1993)	*
		±0.25	±0.0020	±1.3	±0.60	±6.7	±0.012	±64.			
05542−2909	FIN 382	31.60	0.243	109.2	199.6	1985.9	0.215	331.	3	Cvetkovic (2008b)	
		±0.48	±0.014	±1.9	±4.0	±1.4	±0.023	±11.			
06003−3102	TOK 9 CE	23.700	0.55	95.2	147.	1999.8	0.35	270.	5		*
06173+0506	CAT 1 Aa,Ab	32.07	0.598	35.6	163.1	1998.05	0.796	75.0	5	Catala et al. (2006)	*
06274−2544	B 114	59.66	0.4222	19.8	164.	1977.24	0.541	14.	3	Cvetkovic et al. (2008)	
		±0.50	±0.0047	±3.4	±21.	±0.79	±0.013	±24.			
06439−5434	HDS 934	12.371	0.140	30.	94.	2014.0	0.275	68.	3		*
		±0.040	±0.016	±21.	±36.	±1.0	±0.075	±13.			
06485−1226	A 2935	111.50	0.272	119.5	151.0	2002.34	0.227	143.8	4	Olevic & Cvetkovic (2005)	
06573−4929	RST 5253 AB	48.83	0.205	67.2	149.7	2013.10	0.046	141.5	4	Costa (1975)	*
07079−1542	A 3043	113.9	0.184	31.	201.	1960.8	0.781	300.	3	Docobo & Prieto (1991)	
		±5.8	±0.023	±15.	±28.	±2.2	±0.052	±25.			
07185−5721	HDS 1013 Aa,Ab	60.68	0.365	23.6	180.7	1998.81	0.237	303.5	4		*
07322+1405	HU 1244	145.81	0.321	131.9	125.1	1898.55	0.584	6.0	4	Ling & Prieto (1988)	
07374−3458	FIN 324 AC	81.2	0.3205	160.	254.	2016.60	0.642	24.	3		*
		±2.0	±0.0061	±12.	±14.	±1.00	±0.030	±13.			
08251−4910	RST 321	25.76	0.3057	42.7	126.7	2000.99	0.225	235.8	2	Worley (1981)	
		±0.11	±0.0065	±2.5	±2.7	±0.42	±0.024	±7.1			
08263−3904	B 1605 Ba,Bb	96.3	0.1839	151.7	74.	2021.8	0.035	330.	3		*
		±2.6	±0.0063	±6.0	±17.	±8.9	±0.034	±44.			
08280−3507	FIN 314 Aa,Ab	68.0	0.1285	65.2	234.7	2000.3	0.175	86.	3		*
		±4.2	±0.0051	±3.2	±2.2	±1.7	±0.042	±15.			
08380−0844	HDS 1242	30.80	0.243	40.0	232.0	2014.39	0.544	248.7	4		*
08421−5245	B 1624	74.14	0.4445	70.02	90.77	1997.79	0.2136	13.9	3	Mason et al. (1999)	*
		±0.66	±0.0039	±0.40	±0.42	±0.47	±0.0063	±2.7			
08447−4238	CHR 238	2.258	0.0754	154.39	189.21	2012.574	0.6707	122.67	2	Goldin & Makarov (2007)	*
08486+0237	A 2551	70.7	0.141	38.5	281.	1950.52	0.675	303.	3	Mason & Hartkopf (2001)	
		±1.4	±0.011	±9.8	±14.	±0.66	±0.047	±15.			
08538−4731	FIN 316	7.2278	0.07833	13.9	277.	2007.624	0.2557	299.0	2	Söderhjelm (1999)	
		±0.0089	±0.00058	±3.0	±10.	±0.037	±0.0040	±9.1			
08589+0829	DEL 2	5.66	0.424	109.9	274.3	2006.73	0.707	30.2	4		*
09387−3937	I 202	160.33	0.940	110.8	178.7	2006.10	0.419	206.7	4	Seymour et al. (2002)	*
09535+1657	CHR 219	43.57	0.305	103.6	241.7	2021.51	0.428	260.8	4		
10000+2433	CHR 145	44.13	0.437	96.3	197.5	2003.21	0.748	271.6	4		*
10282−2548	FIN 308 AB	32.83	0.1375	44.4	152.	2017.89	0.722	92.4	3	Docobo (1991)	*
		±0.39	±0.0012	±7.9	±12.	±0.82	±0.045	±7.2			
10465−6416	FIN 364 AB	13.27	0.0760	113.6	134.5	2011.4	0.0504	304.	3	Mante (2003)	*
		±0.17	±0.0029	±3.2	±1.8	±1.3	±0.0027	±39.			
10529−1717	HDS 1556	14.56	0.164	100.9	110.8	2002.4	0.50	43.	3		*
		±0.42	±0.041	±6.7	±2.9	±1.8	±0.14	±27.			
11009−4030	FIN 365	45.80	0.13774	70.83	99.95	1996.13	0.2983	261.0	3		*
		±0.62	±0.00030	±0.40	±0.20	±0.11	±0.0044	±1.2			
11102−1122	HDS 1590	20.57	0.153	125.2	278.0	1994.27	0.781	81.6	4		*
13317−0219	HDS 1895	3.2448	0.0938	10.	315.2	1994.324	0.551	352.3	2		*
		±0.0052	±0.0034	±13.	±4.5	±0.023	±0.012	±4.2			
13527−1843	WSI 78	6.22	0.031	67.7	125.7	1982.44	0.465	183.7	4		*
16391−3713	FIN 340 AB	46.9	0.174	78.95	142.1	2009.8	0.119	48.2	3		*
		±1.2	±0.010	±0.81	±1.9	±2.8	±0.094	±23.6			

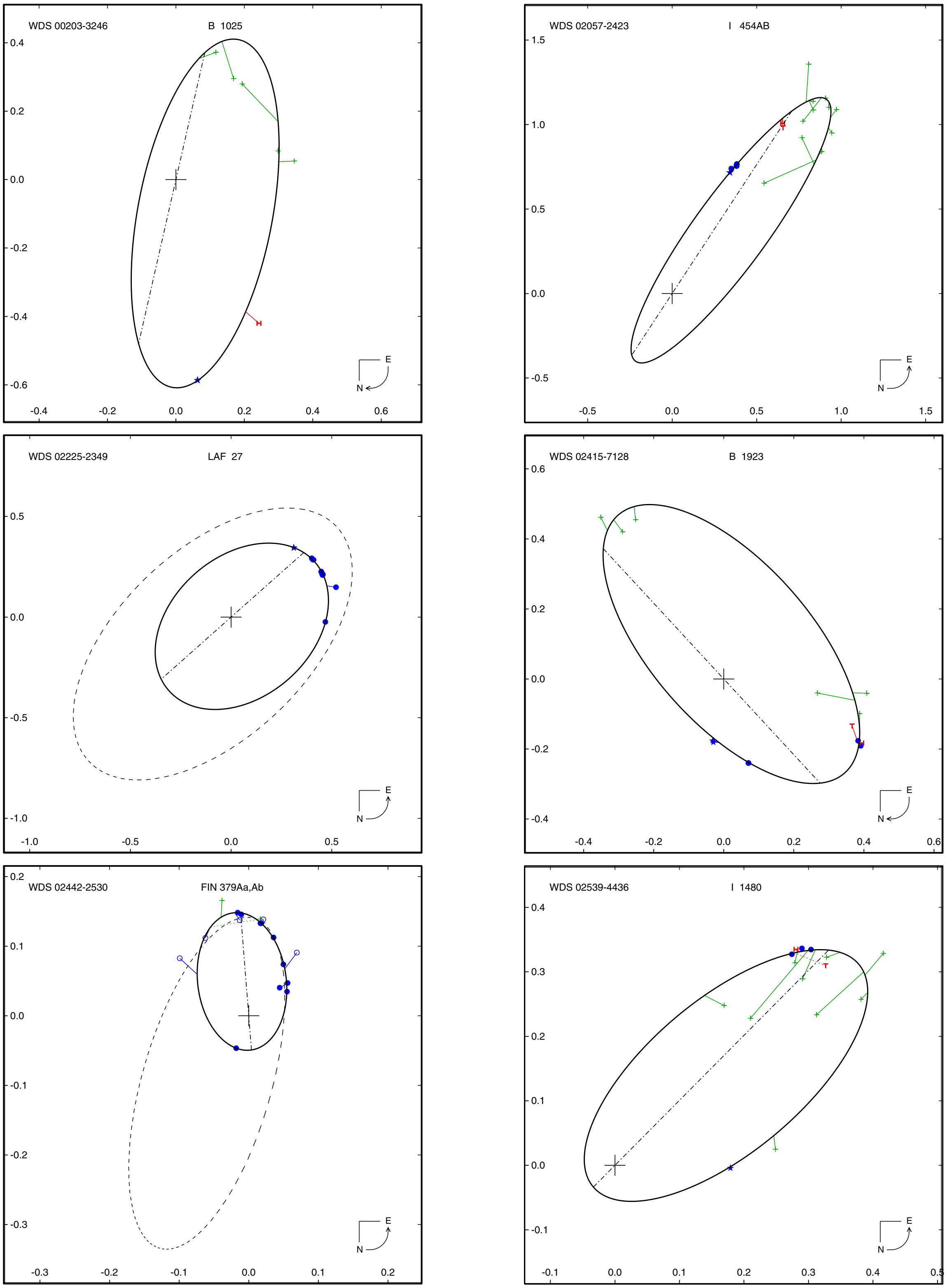

Figure 3. New orbits for the systems listed in Table 3, together with all published data in the WDS database. See the text for a description of symbols used in this and the following figures.

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

01187−2630 = HIP 6136 = TOK 182 Ba,Bb. This is a new subsystem in the SEE 11 AB pair, with a very faint companion Bb at 0.″39 from Ba. The AB pair was observed but not detected as a triple in 2008 (TMH10).

01308−5940 = HIP 7040 = TOK 183. A new close companion at 0.″05 is found. This is a nearby G0V dwarf with variable RV.

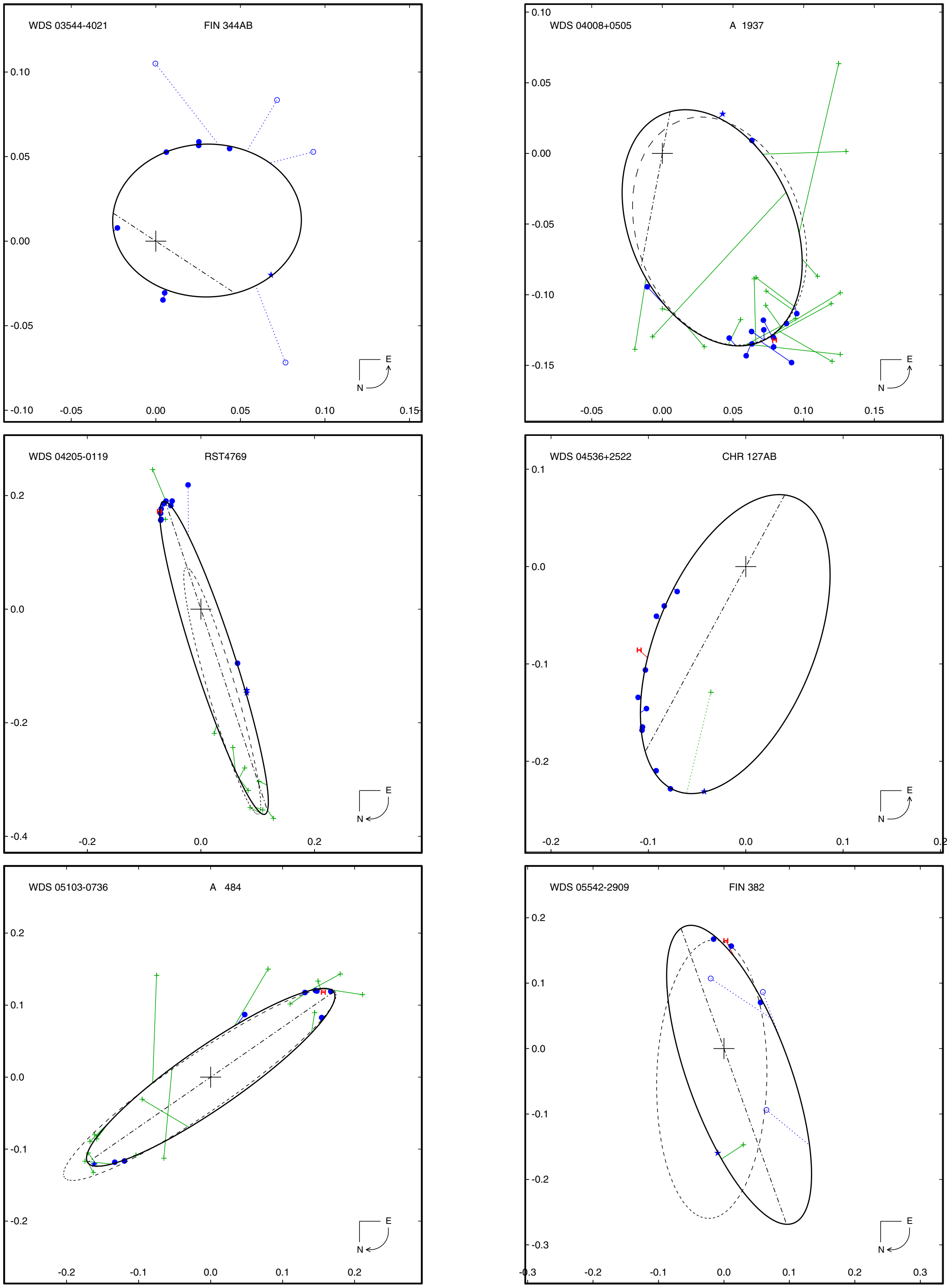

Figure 3. (Continued)

01417−1119 = HIP 7916 = STF 147. This pair has closed from ∼4″ in the early 1820s to 0″.1 in 2009 and now 50 mas in 2011. Nearly two centuries of motion have been well characterized by a rectilinear fit to those data. However, a noticeable acceleration has been seen in recent observations, as the large residuals to that linear fit in Table 2 will attest. Observations over the next few years should allow better definition of this apparently physical pair.

01496−4646 = HIP 8498 = TOK 184. A faint companion at 0″.25, $\Delta I = 3.9$ mag, is found. It is unresolved in the

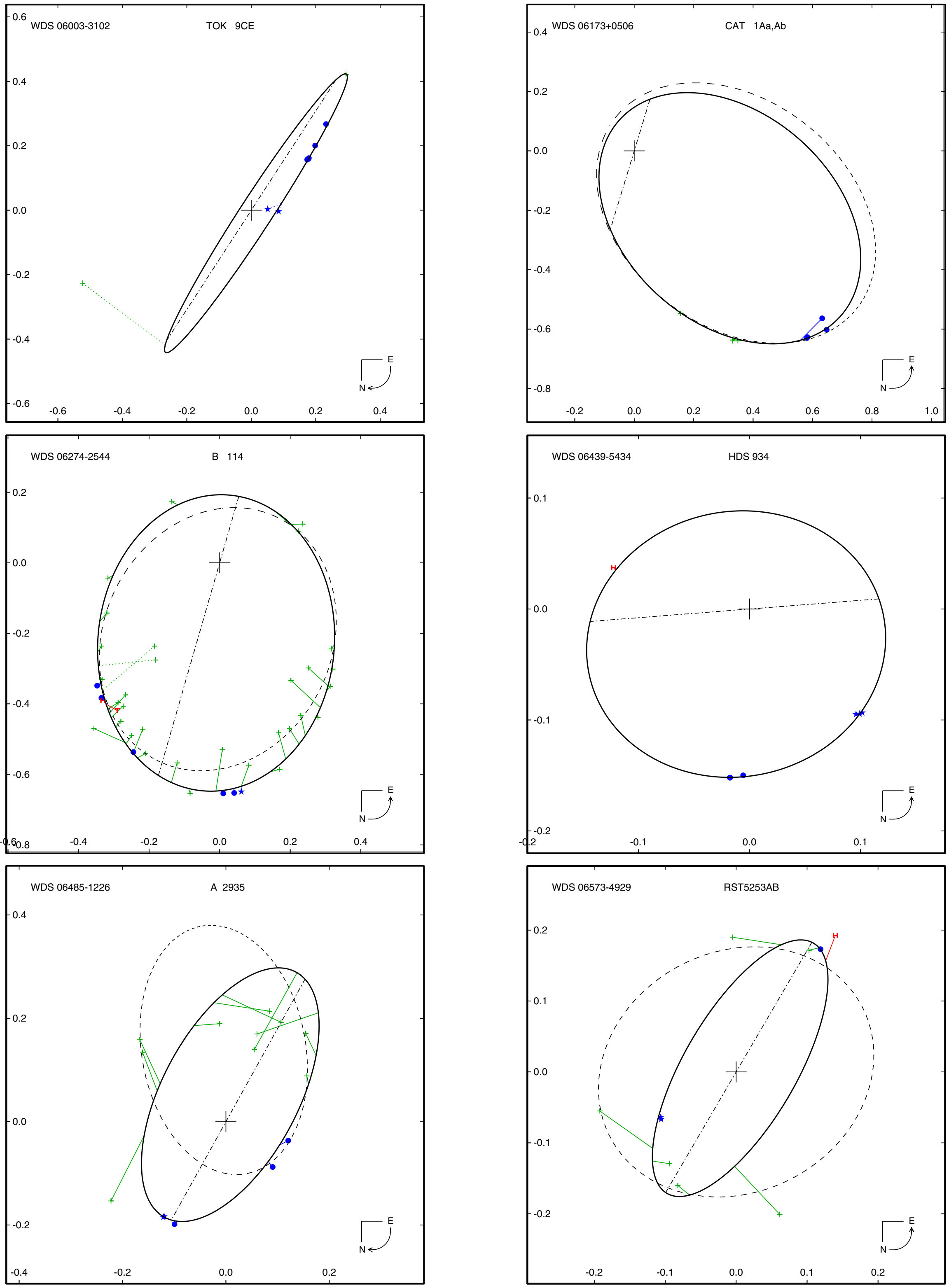

Figure 3. (Continued)

y filter. This G5V dwarf is already known as an astrometric and spectroscopic binary. The estimated period is on the order of 50 years.

02057−2423 = HIP 9774 = I 454. A preliminary orbit of the AB pair in this quadruple yields a period of just over 200 years. The subsystem WSI 71 Aa,Ab is too close to be resolved here; its preliminary orbit in SAM10 predicts a separation of 14 mas.

02166−5026 = HIP 10611 = TOK 185. The companion at 0″.05 is resolved here for the first time. This is a nearby G5V dwarf previously known as an astrometric binary.

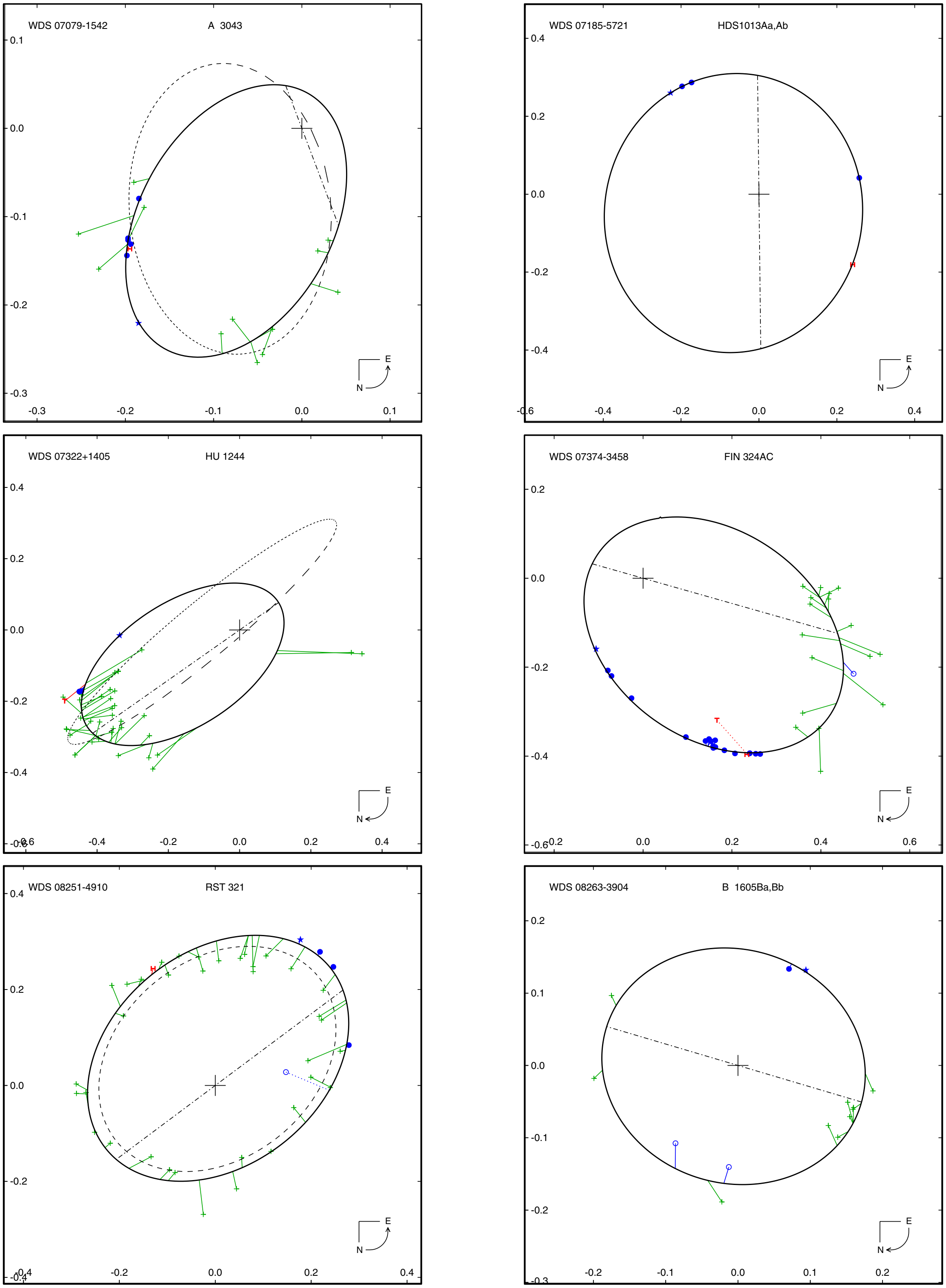

Figure 3. (Continued)

02225−2349 = HIP 11072 = LAF 27. This is the nearby G dwarf κ For, an astrometric binary with P = 26.5 years. It was first resolved at SOAR in 2007. Our orbital solution fixes P and e to the astrometric values derived by Gontcharov & Kiyaeva (2002). This orbit must be considered preliminary, due to the lack of phase coverage, but the resulting mass sum is in reasonably good agreement with the values expected for a G1V + early-M pair.

02374−5233 = HIP 12225 = η Hor = TOK 186 Aa,Ab. The near-circular three-year astrometric orbit of Goldin & Makarov

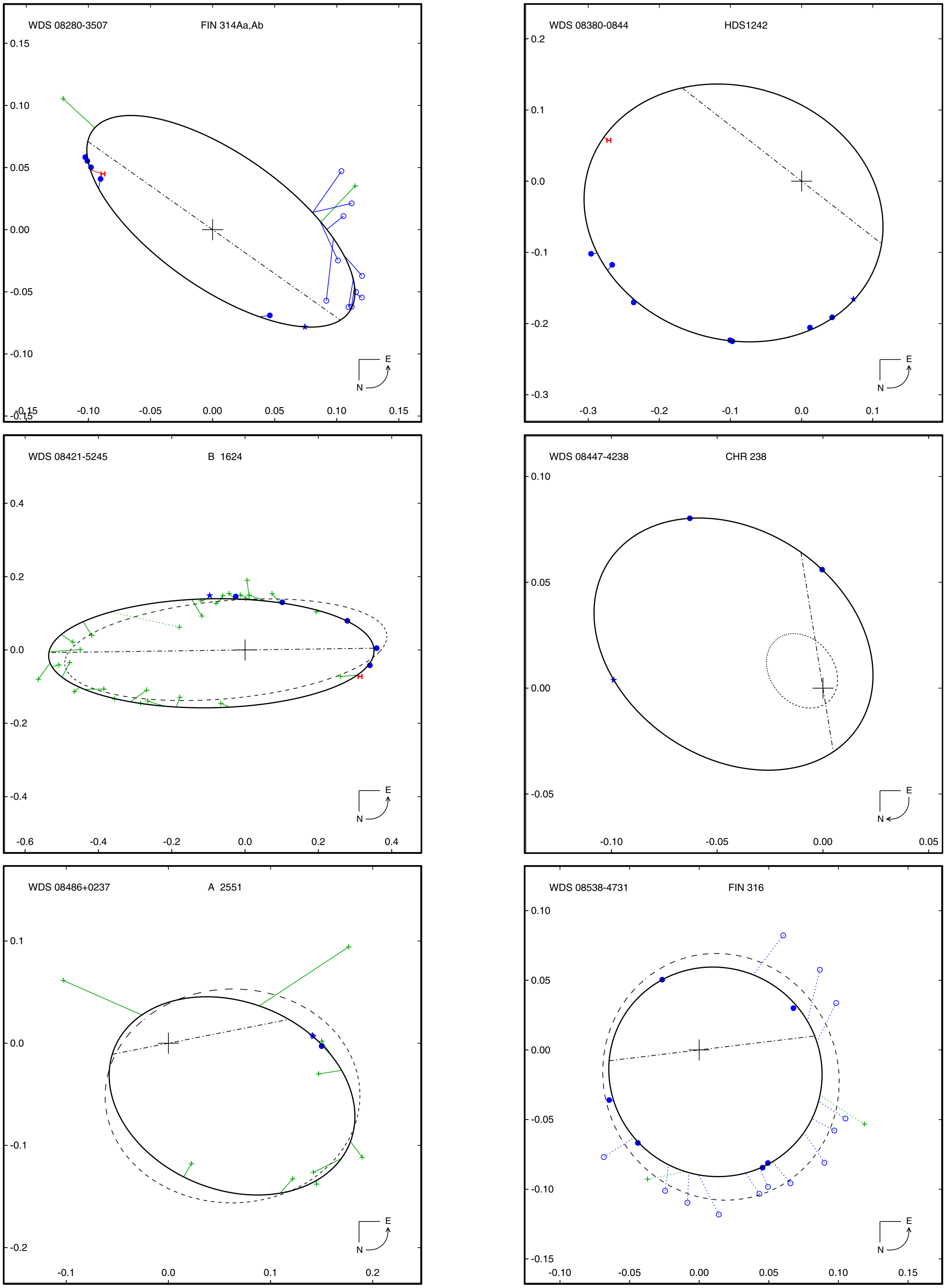

Figure 3. (Continued)

(2007) implies a semimajor axis on the order of 70 mas, given the *Hipparcos* parallax. The astrometric orbit predicts a photocenter displacement of 21 mas at 71° while we measure a separation of 70 mas at 60° and $\Delta y = 1.4$ mag. Frequent measures of this nearby and apparently young system with debris disk are needed to confirm the orbit and to compute masses.

02415−7128 = HIP 12548 = B 1923. This is a nearby G dwarf; the companion is perhaps early-K. The orbit

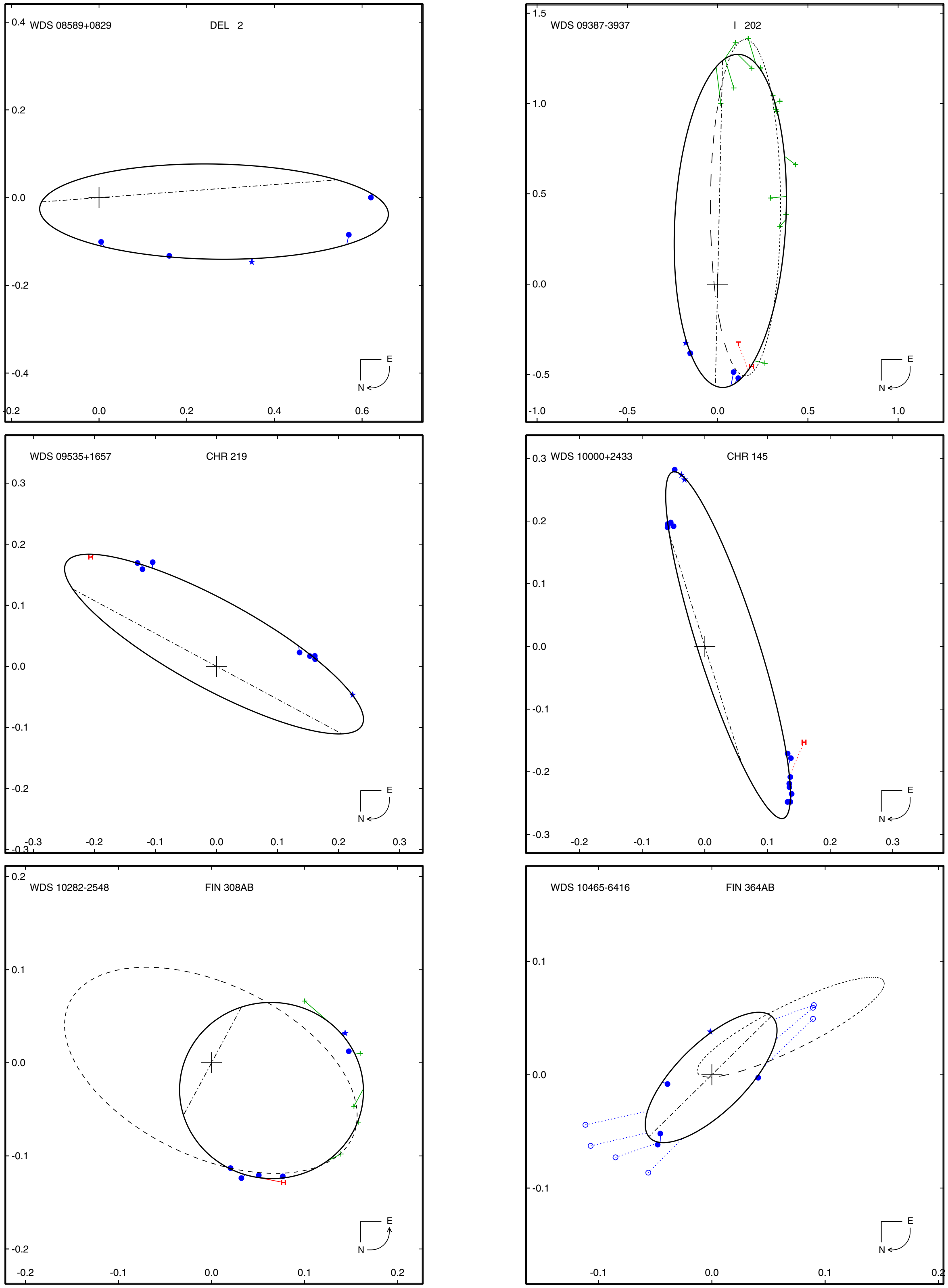

Figure 3. (Continued)

($P \sim 100$ years) given in Table 4 must be considered preliminary, but yields a reasonable mass sum.

02434−3756 = HIP 12716 = TOK 187. This is a nearby dwarf triple; the primary is G6V. The new companion at 0$''$.38 with $\Delta I = 3.3$ mag resolved here should correspond to the astrometric binary discovered by Makarov & Kaplan (2005). The estimated period is 40 years. The A component is the SB2 UX For with 0.955 day period, also an X-ray source (MSC).

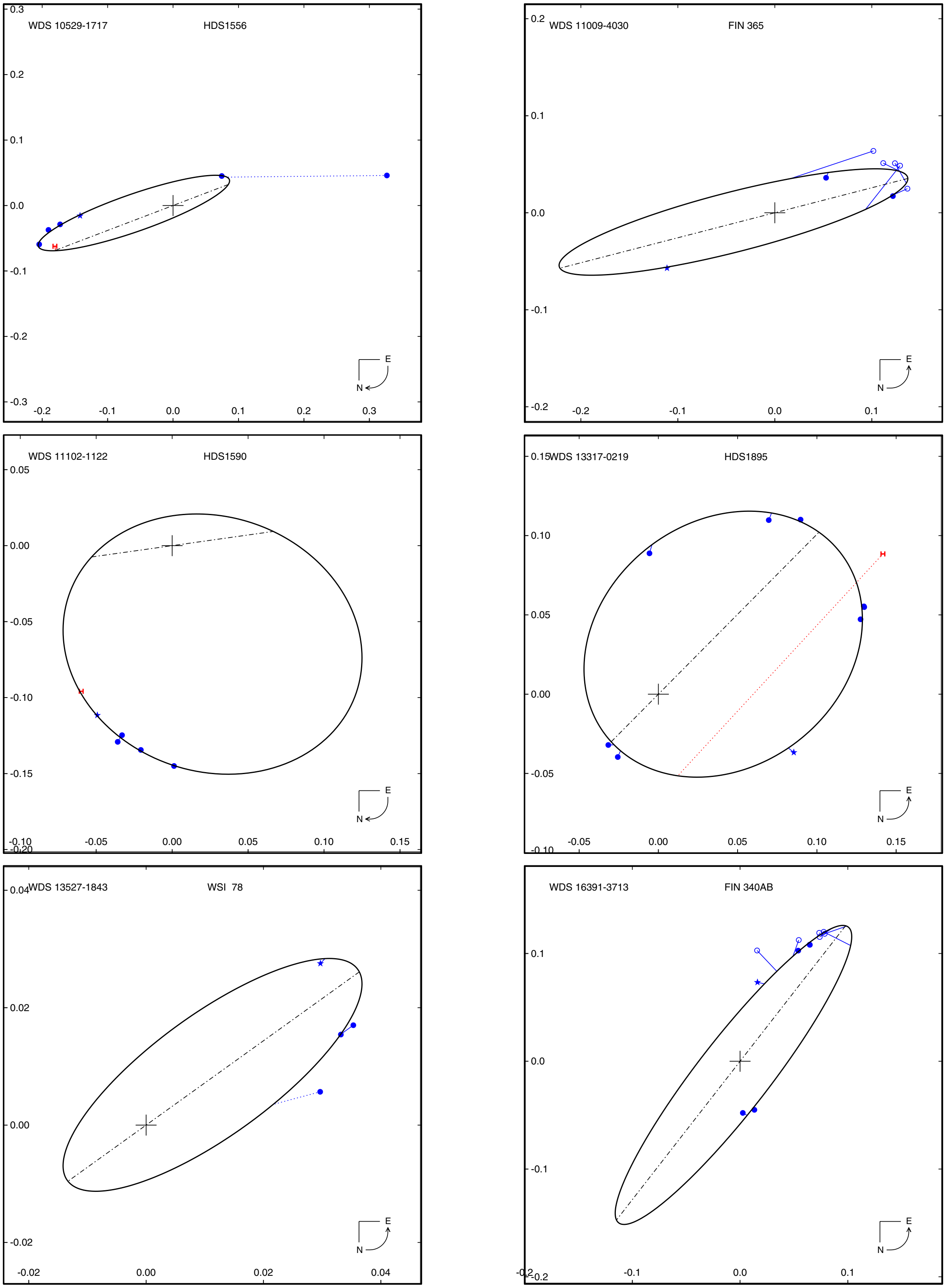

Figure 3. (Continued)

02442−2530 = HIP 12780 = FIN 379 Aa,Ab. This comprises the close pair in a physical triple. Combined with the *Hipparcos* parallax (24.2 ± 1.6 mas) the orbit in Table 4 yields a mass sum of 1.55 $M_\odot$ (the expected value is ~2.1 $M_\odot$). If we adopt the *Hipparcos* parallax, we can place the triple system on the color–magnitude diagram (K, $V - K$). The Aa,Ab is ~1 mag above the main sequence (MS), as expected, and B is on the MS. If we instead adopt the dynamical parallax, the stars will move up by 0.2 mag. It is likely that the *Hipparcos* parallax was biased slightly, due to the rapid motion of the binary.

Table 5
Orbital Ephemerides

WDS	Discoverer	2012.0		2014.0		2016.0		2018.0		2020.0	
Designation	Designation	θ (°)	ρ (″)	θ (°)	ρ (″)	θ (°)	ρ (″)	θ (°)	ρ (″)	θ (°)	ρ (″)
00203−3246	B 1025	5.4	0.595	3.8	0.602	2.2	0.607	0.6	0.609	359.0	0.608
02057−2423	I 454 AB	155.1	0.760	156.4	0.697	158.0	0.631	159.9	0.561	162.5	0.487
02225−2349	LAF 27	149.8	0.424	183.6	0.320	238.1	0.286	282.4	0.374	308.7	0.457
02415−7128	B 1923	340.1	0.158	303.7	0.148	273.3	0.185	255.5	0.244	244.8	0.307
02442−2530	FIN 379 Aa,Ab	188.2	0.149	228.3	0.099	81.7	0.048	177.0	0.141	209.9	0.129
02539−4436	I 1480	95.1	0.212	102.8	0.268	107.9	0.316	111.8	0.356	115.0	0.390
03544−4021	FIN 344 AB	84.3	0.080	102.2	0.087	119.3	0.084	140.0	0.072	172.6	0.053
04008 + 0505	A 1937	148.8	0.036	283.3	0.027	336.6	0.062	352.3	0.089	1.4	0.109
04205−0119	RST 4769	26.8	0.189	24.6	0.231	23.1	0.267	21.9	0.298	20.9	0.324
04536 + 2522	CHR 127 AB	351.1	0.232	354.2	0.224	357.5	0.215	1.2	0.203	5.4	0.190
05103−0736	A 484	304.8	0.208	300.8	0.197	295.7	0.165	287.1	0.117	263.6	0.062
05542−2909	FIN 382	345.1	0.119	283.1	0.069	224.9	0.123	206.2	0.182	94.6	0.195
06003−3102	TOK 9 CE	348.2	0.099	303.0	0.119	207.4	0.107	174.9	0.235	165.4	0.355
06173 + 0506	CAT 1 Aa,Ab	49.6	0.887	54.6	0.888	59.7	0.873	65.1	0.840	71.0	0.791
06274−2544	B 114	7.6	0.631	12.0	0.616	16.6	0.596	21.6	0.572	27.1	0.543
06439−5434	HDS 934	75.5	0.126	158.5	0.090	254.0	0.126	298.9	0.159	335.4	0.158
06485−1226	A 2935	324.8	0.220	320.0	0.218	315.1	0.212	309.8	0.205	304.1	0.195
06573−4929	RST 5253 AB	306.9	0.143	316.5	0.171	323.7	0.190	330.0	0.197	336.3	0.192
07079−1542	A 3043	320.7	0.289	322.1	0.291	323.5	0.292	324.8	0.293	326.1	0.294
07185−5721	HDS 1013 Aa,Ab	227.1	0.351	238.2	0.361	248.7	0.372	258.7	0.381	268.1	0.391
07322 + 1405	HU 1244	271.6	0.331	268.9	0.314	266.0	0.296	262.6	0.278	258.8	0.259
07374−3458	FIN 324 AC	315.2	0.173	287.7	0.139	246.2	0.116	196.3	0.118	157.8	0.148
08251−4910	RST 321	157.2	0.335	175.2	0.308	197.1	0.278	223.4	0.259	251.6	0.259
08263−3904	B 1605 Ba,Bb	140.2	0.160	131.6	0.162	123.3	0.165	115.2	0.167	107.4	0.170
08280−3507	FIN 314 Aa,Ab	226.9	0.110	231.6	0.099	239.7	0.061	7.5	0.016	47.7	0.077
08380−0844	HDS 1242	39.7	0.160	95.1	0.098	193.1	0.123	228.1	0.201	245.1	0.253
08421−5245	B 1624	223.2	0.190	237.0	0.244	245.7	0.301	251.7	0.355	256.2	0.403
08447−4238	CHR 238	217.2	0.101	230.6	0.114	242.1	0.118	253.8	0.113	267.6	0.099
08486 + 0237	A 2551	96.1	0.133	103.7	0.114	114.7	0.092	134.1	0.065	181.2	0.040
08538−4731	FIN 316	60.4	0.095	147.6	0.065	300.9	0.071	21.9	0.095	86.9	0.087
08589 + 0829	DEL 2	332.8	0.106	91.0	0.618	76.9	0.527	272.7	0.129	88.7	0.651
09387−3937	I 202	326.1	0.331	312.1	0.276	292.3	0.238	268.6	0.231	246.8	0.259
09535 + 1657	CHR 219	75.1	0.241	69.9	0.256	64.9	0.251	58.9	0.212	47.3	0.128
10000 + 2433	CHR 145	185.5	0.262	181.8	0.234	176.9	0.201	170.1	0.165	159.4	0.130
10282−2548	FIN 308 AB	108.2	0.134	121.2	0.121	137.0	0.111	155.2	0.106	173.9	0.108
10465−6416	FIN 364 AB	147.7	0.064	123.8	0.081	88.4	0.046	349.5	0.048	316.4	0.082
10529−1717	HDS 1556	268.0	0.102	185.4	0.036	116.6	0.094	313.6	0.047	292.2	0.180
11009−4030	FIN 365	120.2	0.119	127.8	0.103	138.3	0.086	153.7	0.071	176.1	0.060
11102−1122	HDS 1590	325.6	0.111	290.9	0.069	87.8	0.087	64.9	0.136	51.3	0.155
13317−0219	HDS 1895	121.1	0.144	22.8	0.057	151.3	0.131	100.1	0.127	215.3	0.066
13527−1843	WSI 78	147.8	0.027	357.9	0.010	121.0	0.043	143.1	0.031	326.3	0.013
16391−3713	FIN 340 AB	178.3	0.059	261.3	0.036	318.0	0.062	356.6	0.051	58.3	0.049

Table 6
New Rectilinear Elements

WDS Designation	Discoverer Designation	x_0 (″)	a_x (″ yr^{-1})	y_0 (″)	a_y (″ yr^{-1})	T_0 (yr)	ρ_0 (″)	θ_0 (deg)	Note
04130−2832	HWE 10	0.786	−0.0035	0.285	0.0097	2131.895	0.84	109.9	
04257−0214	BU 403	0.167	−0.0093	−0.422	−0.0037	2100.703	0.45	21.6	
04375 + 1509	CHR 153	0.196	0.0124	−0.107	0.0228	1993.139	0.22	61.4	*
05019−7638	RST 2368	0.579	−0.0062	0.484	0.0075	1984.973	0.76	129.9	
05245−0224	DA 5 AB	0.167	0.0047	0.349	−0.0022	1675.997	0.39	154.4	*
07378−0236	A 534 AB,C	−0.280	−0.0040	0.245	−0.0046	1782.212	0.37	228.7	
07448−3344	STN 9001	0.819	0.0068	−0.383	0.0146	2054.816	0.91	64.9	
13064 + 2109	COU 11 AB	0.158	−0.0112	−0.206	−0.0086	1886.671	0.26	37.6	*
13175−4033	I 425	0.115	0.0070	−0.120	0.0067	2034.660	0.17	43.8	

02449 + 1007 = HIP 12828 = TOK 1. This is not resolved here. It must have closed in since its last observation on 2008.77 (0$''$.1, $\Delta y = 3.5$ mag, TMH10).

02539−4436 = HIP 13498 = I 1480. This is the wide pair in a triple system; the A component is an SB2 without published orbit, and also an X-ray source (MSC). An initial orbit for AB

Table 7
Linear Ephemerides

WDS Designation	Discoverer Designation	2012.0 θ (°)	2012.0 ρ (″)	2014.0 θ (°)	2014.0 ρ (″)	2016.0 θ (°)	2016.0 ρ (″)	2018.0 θ (°)	2018.0 ρ (″)	2020.0 θ (°)	2020.0 ρ (″)
04130−2832	HWE 10	54.1	1.489	54.5	1.472	55.0	1.455	55.5	1.438	55.9	1.421
04257−0214	BU 403	84.5	0.994	83.9	0.976	83.4	0.958	82.8	0.941	82.2	0.924
04375+1509	CHR 153	126.8	0.538	128.9	0.586	130.7	0.634	132.3	0.683	133.6	0.732
05019−7638	RST 2368	149.0	0.799	150.3	0.806	151.6	0.813	152.9	0.820	154.1	0.828
05245−0224	DA 5 AB	77.0	1.785	76.9	1.796	76.8	1.806	76.8	1.816	76.7	1.826
07378−0236	A 534 AB,C	303.8	1.448	304.0	1.459	304.1	1.471	304.2	1.483	304.3	1.495
07448−3344	STN 9001	27.7	1.137	29.0	1.118	30.3	1.099	31.7	1.081	33.2	1.064
13064+2109	COU 11 AB	315.9	1.790	315.8	1.818	315.7	1.846	315.5	1.874	315.4	1.902
13175−4033	I 425	350.9	0.276	353.5	0.260	356.4	0.246	359.7	0.232	3.3	0.219

finds a period of about 50 years. The primary is a K0:III; the derived mass sum and magnitude difference are both consistent with a late-A dwarf companion.

02572−2458 = HIP 13772 = BEU 4 Ca,Cb. This shows fast motion. This pair and BU 741 belong to the low-mass quintuple system GJ 120.1 (MSC).

03099−0654 = HIP 14699 = TOK 188 Aa,Ab. This is the W-UMa-type eclipsing binary UX Eri. The new close companion at 0.″044 appears real, based on examination of other stars observed contemporaneously. This tertiary companion was suspected from eclipse timing, but was unresolved with AO by Rucinski et al. (2007), probably being too close.

03167−0332 = HIP 15247 = TOK 189 Aa,Ab. A new faint red companion is found at 0.″88, $\Delta I = 3.5$ mag, $\Delta y = 5.2$ mag, estimated period 200 years. This is a young nearby F5 dwarf with variable RV, possibly triple, and also an X-ray source.

03309−6200 = HIP 16370 = TOK 190. This is resolved for the first time at 0.″07. It is a nearby F7V dwarf, an astrometric and spectroscopic binary, and an X-ray source.

03442−6448 = HIP 17440 = TOK 191 Aa,Ab. This is the nearby star HR 1175 = β Ret, K2III. The new companion resolved at 0.″08, $\Delta I = 2.8$ mag may correspond to the 5.2 year astrometric subsystem found by Ramm et al. (2009) with estimated semimajor axis of ∼0.″15. However, its non-resolution in y is strange, given the red color of the primary.

03544−4021 = HIP 18262 = FIN 344. This consists of a K0III and A3V stars; a preliminary orbit yields a period of 14 years and a mass sum of 4.2 $M_\odot$. The primary has variable RV.

04049−3527 = = HIP 19052 = CHR 224 BC. This shows fast motion, estimated period 10 years. Together with I 152 AB this is a hierarchical resolved triple system.

04205−0119 = HIP 20257 = RST 4769. Table 4 updates the orbit of Heintz (1997) for this pair of A3 dwarfs; the predicted mass sum of 3.5 $M_\odot$ is a little low.

04286+1558 = HIP 20885 = MCA 15. This was resolved, but no consistent measure could be obtained because of large $\Delta y \sim 3$ mag and the influence of vibrations. This pair belongs to the quadruple system HR 1412+1411.

04375+0509 = HIP 21543 = CHR 153. This is a triple Hyades dwarf. The inner 1.8 year astrometric/spectroscopic subsystem is not resolved. Recent measures showed significant runoff from the solution of Olevic & Cvetkovic (2003b); the data appear to be better described by a simple rectilinear fit (see Figure 4(a)), suggesting the companion is just another Hyades member projected close to the primary. A non-Hyad background star is ruled out, as it would have moved by ∼20″ since discovery.

04422+0259 = HIP 21880 = A 2424. This is unresolved despite $\Delta m = 0.46$ mag and a separation of 0.″15 predicted by the orbit of Wilson (1976).

04536+2522 = HIP 22747 = CHR 127. This is resolved, but no trace of the subsystem A 184 AC is seen here. Motion of the AB pair appears to be well fit by a ∼60 year period orbit.

05245−0224 = HIP 25281 = DA 5 AB. This is the quadruple star HR 1788 = η Ori; A is an eight-day SB2 with a spectroscopic tertiary companion known as MCA 18. This subsystem, with a 9.44 year period, is unresolved here and in TMH10.

05353−0523 = HIP 26221 = WGT 1 Ca,Cb. θ Ori C was apparently resolved during SAM tests in November, but we are not certain of the identification; it could have been another star in the trapezium.

05418−5000 = HIP 26830 = HU 1568. This is composed of a pair of early-K dwarfs. A preliminary 300 year period orbital solution yields a mass sum consistent with these types.

05540+1225 = HIP 27878 = TOK 192 Aa,Ab. A new faint companion is found at 1.″4, $\Delta I = 5.7$ mag, unresolved in the y filter. This is a nearby quadruple F8 dwarf containing a spectroscopic subsystem and a CPM companion at 90″.

06003−3102 = HIP 28442 = TOK 9 CE. This was discovered in 2004 on AO-corrected images in the IR (Tokovinin et al. 2005). Later it was resolved at SOAR in the visible. It is marginally resolved here in the I band (0.″08) and has closed down as expected. The second observation on 2010.966 gave unrealistically small separation with a small Δm derived from the power-spectrum fit. The CE pair follows a ∼23 year preliminary orbit (Table 4) and, together with HU 1399, belongs to the quadruple system of nearby dwarfs GJ 225.2 with high proper motion.

06032+1922 = HIP 28671 = HDS 823 Aa,Ab. This belongs to a nearby G-type triple system with a physical tertiary at 6.″9; its estimated orbital period is ∼10 years. The pair has opened up after passing through periastron; it was unresolved in TMH10.

06173+0506 = HIP 29860 = CAT 1 Aa,Ab. This is a G0V star at 19.3pc from the Sun with four companions listed in the WDS. Three (B, C, D) are optical, but LEP 24AE at 103″ is physical. The inner Aa,Ab pair was discovered as a spectroscopic binary by Vogt et al. (2002), who proposed an orbital solution with a period of 33.7 ± 1.5 years. Their observations cover only 10% of the period around periastron.

The system was first resolved in the IR by Catala et al. (2006) using the PUEO AO system. They revised the period to 28.8 ± 1.1 years by fitting a combined spectro-visual orbit to all the data; other elements were $a = 0.''621$, $i = 35.^\circ4$, and $\Omega = 166.^\circ8$. They estimated that the companion with $\Delta V \sim 5.5$ mag is not

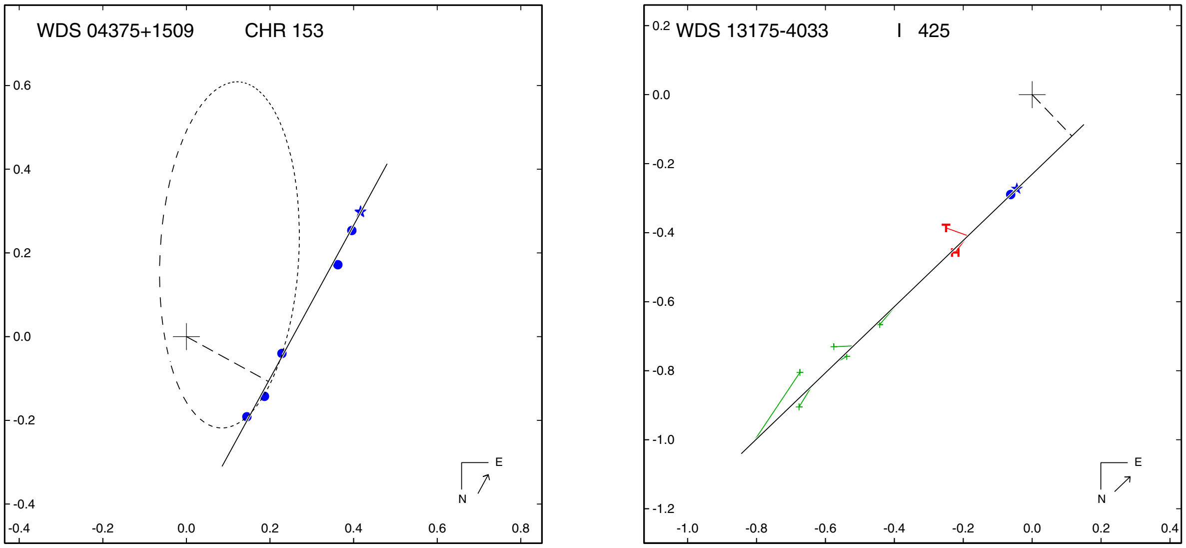

Figure 4. Rectilinear fits to (left) WDS 04375 + 0509 = CHR 153 and (right) WDS 13175−4033 = I 425. Symbols are the same as in the orbit figures above, but here the dashed line indicates the time of closest apparent separation. Linear elements appear to describe the relative motion of the Hyades pair CHR 153 much better than the orbital solution of Olevic & Cvetkovic (2003b). I 425 is noteworthy in that the fit predicts a minimum apparent separation of only 166 mas in 2034.

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

detectable in the visible. However, we measured it in TMH10 and here, with $\Delta y = 5.2$ mag.

A slight runoff of the residuals prompted us to adjust the orbital elements. The seven Campbell elements are in Table 4, other spectroscopic elements are $K_1 = 4325.00 \pm 5.81$ km s^{-1} and $V_0 = 457.11 \pm 10.97$ km s^{-1}. This orbit, combined with the *Hipparcos* parallax, lead to a mass sum of 1.50 $M_\odot$. Lower weight was given to our measure obtained on a technical night on 2008.773, because of a large residual in position angle (P.A.).

06290 + 2013 = HIP 30883 = ν Gem = BTZ 1. Our measure confirms the 18 year orbit by Cvetkovic & Ninkovic (2008) and casts doubt on the 9.6 year spectroscopic orbit based on poor-quality data. The pair BU 1192 Ba,Bb also measured here may form a physical quadruple with BTZ 1, but most likely it is optical.

06439−5434 = HIP 32242 = HDS 934. The nearby K-dwarf pair shows quite rapid motion, and has completed nearly two revolutions since its discovery in 1991. We compute its orbit with P = 12.37 years (Table 4) which matches the expected mass sum.

06573−4929 = HIP 33455 = RST 5253 AB. The update to the solution of Costa (1975) yields a mass sum of 2.1 $M_\odot$, in excellent agreement with the values expected for a G5/6III primary and an early-G companion.

07043−0303 = HIP 34110 = A 519. This is a nearby triple G-dwarf containing a 5.7 day SB1 subsystem. It was not resolved here despite predicted separation of 0.″07; the visual orbit of Docobo & Ling (2009b) therefore needs revision.

07185−5721 = HIP 35374 = HDS 1013 Aa,Ab. This is a nearby G0V dwarf with perhaps a mid-G companion. This close 60 year pair (see the new orbit in Table 4) forms a quadruple system with RST 244 Ba,Bb at 2.″5. We do not resolve the Ba,Bb pair here.

07187−2457 = HIP 35415 = FIN 313 Aa,Ab. This is a quadruple star containing a 1.3 day eclipsing binary Ab and a 155 day SB Aa (MSC). Its distant (0.″95) companion C also measured here may be just another member of the cluster NGC 2362.

07277 + 2127 = HIP 36238 = MCA 30 Aa,Ab. This belongs to a nearby multiple system with five components. It was not resolved here or in TMH10 despite predicted separation of 0.″044 and Δm = 1 mag. The orbit of Muterspaugh et al. (2010) appears very reliable, however.

07374−3458 = HIP 37096 = FIN 324. This is a triple system with comparable separations (“trapezium”) according to the WDS. However, we figured out that all published speckle measures (except one) refer to the AC pair. Its motion appears to be reasonably well fit by an 80 year orbit (Table 4 and Figure 3). The existence of the component B with 0.″1 separation, not seen here and in TMH10, is highly questionable on dynamical grounds, while its historical measures remain unexplained.

07456−3410 = HIP 37853 = TOK 193 Aa,Ab. A new faint red companion at 0.″32, ΔI = 3.0 mag, is found. This nearby F9V dwarf GJ 288A is also known as an astrometric and spectroscopic binary. There is also a physical white dwarf companion at 914″ (Raghavan et al. 2010). Another faint companion at 1.″4, 20° is seen in the y and I filters, but it is not measured here.

07490−2455 = HIP 38146 = TOK 194. Goldin & Makarov (2007) find a three-year astrometric orbit for this G0III star with a parallax of 11.6 ± 1.1 mas. A semimajor axis of 30 mas is expected. At the moment of our resolution (21°, 40 mas, Δy = 1.2 mag) the astrometric orbit predicts a displacement of 16 mas at 164°.

07522−4035 = HIP 38414 = a Pup = TOK 195. This K1.5II giant is a 7 year spectroscopic binary (Parsons 1983). Given the *Hipparcos* parallax of 9.3 ± 0.8 mas, a semimajor axis of 50 mas is expected. An astrometric orbit was determined by Jancart et al. (2005), fixing some elements at their spectroscopic values. This orbit predicts a photocenter displacement by 20 mas at 15° for the moment of our observation. We measured the companion (Δy = 0.8 mag) at 20 mas and 19 deg.

07523−2626 = HIP 38430 = WSI 54. This is resolved here as a binary, with a hint at the triple structure seen in TMH10 in the y filter. This star, of spectral type O6e, belongs to the cluster NGC 2467. Lorenzo et al. (2010) find that the object is quadruple and contains two SB2s.

08151−0655 = HIP 40419 = MET 52. The companion at 1″.43 measured here was first resolved by Metchev & Hillenbrandt (2009) in 2002 at 101°, 1″.23, $\Delta K = 3.9$ mag. This is a nearby G5 dwarf possibly containing an SB subsystem.

08250−4246 = HIP 41250 = CHR 226 Aa,Ab. The quadrant of the close pair is fixed by the wider system AB. Intriguingly, we measure $\Delta y = 2.8$ mag, while $\Delta y = 0.2$ mag was found on 2009.26 by TMH10. The system is variable, with a suspected eclipsing binary.

08263−3904 = HIP 41361 = B 1605 Ba,Bb. This belongs to the quadruple system HR 3327, with Aa,Ab being the 1.3 day eclipsing pair NO Pup (MSC). The A component was observed and found unresolved here and in TMH10. The Ba and Bb components are probably both early-A dwarfs, in an orbit of about a century-long period (Table 4).

08280−3507 = HIP 41515 = FIN 314. This contains the possibly eclipsing subsystem XY Pix (MSC). The ∼36 year period orbit in Table 4 fits the speckle data well, but the early eyepiece interferometry had to be given zero weight in the solution.

08380−0844 = HIP 42345 = HDS 1242. This is a nearby mid-G dwarf (plus early-K companion?) with a period of ∼31 years (Table 4).

08421−5245 = HIP 42695 = B 1624. This is a nearby early-G + early-K dwarf. The revised orbit in Table 4 yields a mass sum of 2.0 $M_\odot$, in reasonable agreement with these types.

08447−4238 = HIP 42916 = CHR 238. This is a nearby pair comprised of a K0: and mid-K dwarfs. Goldin & Makarov (2007) derived an 815 day astrometric orbit with $P = 815$ days and $e = 0.68$. Our orbit, although based on only three measures, is in remarkably good agreement, with $P = 824.7$ days and $e = 0.671$. The derived mass sum is also in quite good agreement with the value expected for these spectral types.

08538−4731 = HIP 43671 = FIN 316. The A component is a 9.1 day SB2 (MSC). The primary spectral type is A9 IV–V; given the magnitude difference of near zero, the secondary is probably similar. In calculating the orbit in Table 4, all data were used to derive the period, then only the higher-quality interferometric data were used in determining all other elements.

08547+1637 = HIP 43751 = TOK 196 Aa,Ab. A new 0″.11 subsystem in AG 338 AB is found in this nearby G5V dwarf. Its estimated period is ∼10 years.

08563−3707 = HIP 43880 = RST 2593. This is a nearby G1 dwarf (secondary perhaps late-K) which has moved by 106° since its discovery in 1935. A preliminary orbit finds a period of about 160 years (Hartkopf & Mason 2011).

08571−2951 = HIP 43947+43946 = TOK 63. Both A and B are close binaries resolved at Gemini (Tokovinin et al. 2010b) and confirmed here at the same positions. This is a quadruple G5V dwarf with an erroneous *Hipparcos* parallax of 26 mas (the true parallax is about 10 mas); the parallax error is likely caused by the companions, unknown at the time of the *Hipparcos* data reduction.

08589 + 0829 = GJ 3522 = DEL 2. This is a nearby M-dwarf pair with a 7.6 day spectroscopic subsystem (MSC). Orbital motion is quite rapid: with 5.7 year period (Table 4), the pair has completed 2.5 revolutions since its discovery in 1997.

09024−6624 = HIP 44382 = TOK 197. This is a nearby HAeBe star and an astrometric binary (Makarov & Kaplan 2005). It is tentatively resolved here into a 0″.032 pair. The reality of the elongation is supported by comparison with other stars observed before and after, but this could still be an artifact (unresolved on 2011.037).

09079−0708 = HIP 44804 = TOK 64 Aa,Ab. This is another subsystem in a nearby triple G-dwarf discovered by Tokovinin et al. (2010b). We see some motion since discovery; the estimated period is ∼130 years.

09128−6055 = HIP 45214 = HDO 207 AB. We corrected the orbit of the AB pair (Mason & Hartkopf 2011a). The subsystem CHR 144 Aa,Ab is unresolved here and in TMH10; it has never been confirmed.

09191−4128 = HIP 45705 = CHR 239. This is a nearby G-dwarf binary with an estimated period ∼10 years, also an astrometric and spectroscopic binary.

09194−7739 = HIP 45734. This is a young quadruple system of spectral type G3 consisting of the 0″.12 pair KOH 83 Aa,Ab resolved here and the SB2 subsystem in the component B, which was also observed and found unresolved.

09228−0950 = HIP 45999 = A 1342. The companion C at 2″ was outside the field, so not measured here.

09380−5924 = HIP 47263. This is a nearby G-dwarf astrometric binary. A tentative companion at 329°, 0″.090, and $\Delta I = 3.0$ mag was detected, but not accepted as real.

09387−3937 = HIP 47328 = I 202. This is a nearby dwarf pair; the primary is F6V, the secondary about G4/5. Recent measures have shown large residuals from the orbit of Seymour et al. (2002), so a new solution was attempted. Although still grade 4 (“preliminary”), the new elements predict a mass sum in excellent agreement with the spectral types.

09412+0954 = HIP 47508 = HMM 1 Aa,Ab. This was unresolved in TMH10 and is marginally resolved here in the *y* filter only at a position roughly consistent with its orbit. The 0″.6 companion ARI 1 Aa,Ac is not seen, it could be bogus.

09416−3830 = HIP 47543 = TOK 198. This is a nearby G2V dwarf with variable RV. A new faint companion is found at 0″.47, $\Delta I = 4.5$ mag, unresolved in *y*. The estimated period of this system is ∼100 years.

10000 + 2433 = GJ 3580 = DH Leo = CHR 145. This is another nearby K-dwarf pair, with orbital period of 44 years similar to that found for CHR 219 (Table 4).

10028+0106 = HIP 49217 = HDS 1451. This is triple, with a 0.4 day eclipsing subsystem Y Sex (MSC). Eclipse timing indicates a tertiary period of 58 years, probably too short for measured separation of 0″.45.

10161−2837 = HIP 50288 = TOK 199. This is a nearby chromospherically active G1V dwarf with variable RV, resolved here at 40 mas.

10232+0542 = HIP 50870. This is a nearby G-dwarf astrometric and spectroscopic binary. We detect a new faint companion at 1″.07, $\Delta I = 5.1$ mag. It is not clear if this is binary or a triple. The visual companion at 63″ is optical.

10282−2548 = HIP 51255 = B 199 + FIN 308. This comprises a resolved triple. The position angle of FIN 308 is different by ∼180 deg from its ephemeris, but quadrant reversal is not allowed by the wide subsystem. We revise its orbit in Table 4.

10311−2411 = HIP 51501 = B 201 AB. This is measured, but the subsystem CHR 132 is not resolved here and in TMH10. This may be a spurious component.

10370−0850 = HIP 51966 = A 556 AB + TOK 44 Aa,Ab. This is a nearby triple G-dwarf. The inner Aa,Ab subsystem was first resolved by Metchev & Hillenbrandt (2009). This pair has closed down from 0″.43 in 2009 to 0″.12 in 2010; its estimated period is ∼10 years.

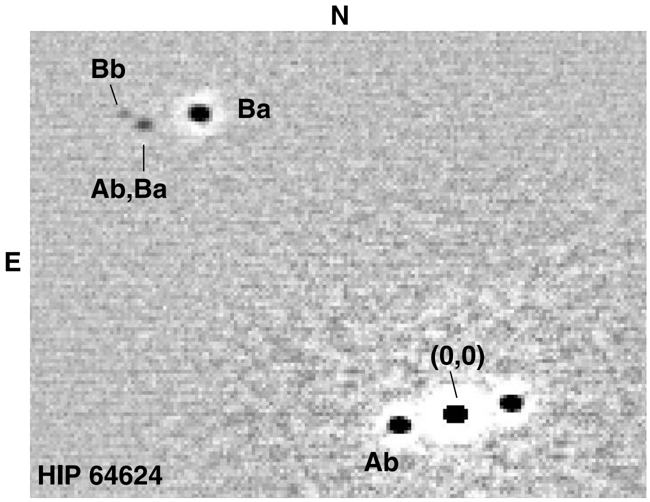

Figure 5. Fragment of the combined ACF of HIP 64624 in the *I* band (negative, arbitrary intensity scaling). The coordinate center is marked (0,0).

10465−6416 = HIP 52701 = FIN 364 AB. This late-B pair, likely a member of the cluster IC 2602, contains a 5.5 day SB1 subsystem (MSC). The faint tertiary TOK 45 AC at 0.″7 is confirmed.

10529−1717 = HIP 53206 = HDS 1556. This is a nearby G-dwarf binary for which we compute the first 14.6 year orbit in Table 4. The one zero-weighted speckle measure was made with the USNO 26 inch, and is close to the resolution limit of that telescope.

11009−4030 = HIP 53840 = FIN 365. This is a nearby F7-dwarf binary with a preliminary orbital period of 46 years (Table 4).

11102−1122 = HIP 54580 = HDS 1590. This is a nearby early-G dwarf binary; the preliminary orbit (Table 4, P = 20.6 years) indicates that it has completed one full revolution since its discovery.

11221−2447 = HIP 55505 = I 507 AB. This is a post-main-sequence quadruple with 262 day and 315 day SB subsystems (MSC) which we do not resolve here. Its first orbit (Tokovinin 1999) could now be improved.

11514+1148 = HIP 57821 = HDS 1672. This was not resolved in TMH10 but now has opened up to 0.″16. It is a nearby G-dwarf with an estimated period ∼10 years.

13064+2109 = HIP 63948 = COU 11 AB. This is resolved here, but the subsystem CHR 150 Aa,Ab is not. The closer pair was seen at 0.″04 on 2009.26.

13081−6518 = HIP 64094 = CHR 247 Aa,Ab. This is marginally resolved with 5 ms exposure time, although the measure could still be affected by vibrations. This is the Wolf–Rayet multiple system θ Mus, containing a 18 day SB2 (MSC).

13147−6335 = HIP 64624. This is an O9V star known previously to be a visual triple. Both the 1.″7 MLO 3 AB pair and the inner WSI 58 Aa,Ab subsystem were measured in TMH10 and here. However, we also see an additional faint peak in the two ACFs in the *I*-band. Figure 5 shows a fragment of two co-added ACFs where we attribute the faint peak to a new companion Bb. A rough measure indicates that the pair Ba,Bb has a separation of 0.″32 and a position angle of 90°, the magnitude difference could be around 3^m (6^m with respect to Aa). The new companion must be redder than the other stars, otherwise it would be seen in the y band. This object is on the list of O-stars surveyed by Mason et al. (2009).

13175−4033 = HIP 64835 = I 425. Although a quite close pair, the motion illustrated in Figure 4(b) suggests that the two components are not physically related. The two stars are predicted to reach a minimum apparent separation of only 166 mas in 2034.

13276+2116 = HD 117078 = TOK 46. This is a quadruple system comprising two SBs (5.5 days and 204 days), first resolved in TMH10. The separation and observed motion (12° in two years) agree with the 36 year period estimated spectroscopically by Griffin (2005).

13317−0219 = HIP 65982 = HDS 1895. This is a late-G (plus mid-K?) dwarf pair and SB1 with a very fast direct motion. We combined interferometric measures with the spectroscopic data of Latham et al. (2002) which are truly complementary. The 3.24 year period is confirmed, the eccentricity is somewhat less than in the SB orbit. The new orbit can be considered very reliable. The *Hipparcos* measure had to be ignored for obvious reason: although the star was indeed resolved, it moved substantially during the *Hipparcos* mission. The fitted separation and angle are reasonable, but their attribution to the average epoch 1991.25 makes no sense. Re-reduction of *Hipparcos* data with the new orbit can lead to a better parallax measurement. Campbell elements are given in Table 4; the additional spectroscopic elements are $K_1 = 2.80 \pm 0.13$ km s^{-1}, $V_0 = -51.13 \pm 0.07$ km s^{-1}.

13527−1843 = HIP 67744 = WSI 78. This has moved by 32° since its first resolution in 2008. It is a spectroscopic triple (Carquillat & Prieur 2007) containing the 1.3 day eclipsing system DL Vir. A very preliminary combined solution was made of the 6.2 year period outer pair; Campbell elements are in Table 4, while the spectroscopic elements are K_1 = 17.45 ± 0.34 km s^{-1}, $V_0 = -22.25 \pm 0.17$ km s^{-1}.

15313−3349 = HIP 76001 = B 2036 AB + HWE 78 AC. This forms a visual triple with comparable separation, 0.″36 and 1.″46. An orbit for the AB pair yields a period of 235 years, although with considerable uncertainty.

16385−5728 = HIP 81478 = V841 Ara = RST 869 AB + TOK 51 Aa,Ab. This is a resolved visual triple at 50 pc from the Sun. The companion B is a hot white dwarf (Wray et al. 1979) and an X-ray source. Its motion hints at an orbital period on the order of 10^3 years. The closer Aa,Ab subsystem was discovered in 2009 (TMH10) and is also measured here in the *I* band, where it is brighter than B ($\Delta I_{\rm Aa,B}$ = 4.7 mag, $\Delta I_{\rm Aa,Ab}$ = 2.7 mag). Therefore the Ab companion is a red dwarf with estimated orbital period ∼20 years.

16391−3713 = HIP 81523 = FIN 340. This is approaching periastron (predicted for mid-2015) with direct motion. The early eyepiece interferometric measures were given zero weight for this preliminary solution with P = 47 years (Table 4).

22116−3428 = HIP 109561 = BU 769 AB. We measure only the pair AB; the 0.″04 subsystem CHR 230 is unresolved here but it was seen in 2008 at 0.″05.

22181−0014 = HIP 110091 = CHR 107. This is resolved at 0.″04. Only one measure is listed in the WDS for this nearby binary G-dwarf with estimated period ∼10 years.

22288−0001 = HIP 110483 = ζ Aqr. This is composed of a 2.″2 visual binary STF 2909 AB with unseen astrometric companion on a 25 year orbit. The companion was tentatively resolved in SAM10, where the A and B components were observed separately and a feature was detected around B. Going back to our logs, we found that A and B were swapped, so the subsystem detected actually belongs to the A-component, and is now designated TOK 201 Aa,Ab. We can see this companion

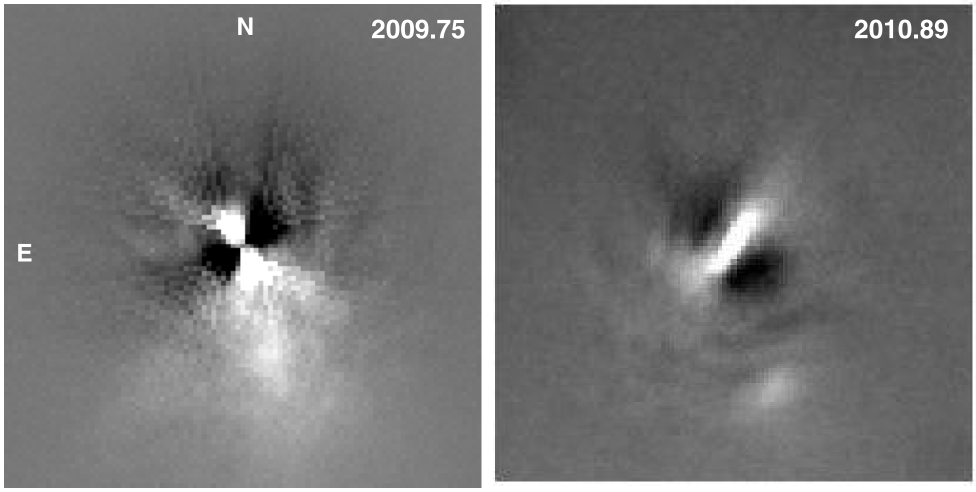

Figure 6. Direct *I*-band images of the astrometric companion to ζ Aqr A. Left: AO-corrected SAA image obtained on 2009.75 with rotationally averaged PSF subtracted. Right: AO-corrected image of the A component obtained on 2010.89 with suitably shifted and scaled image of B subtracted. The size of both images is 1.″55.

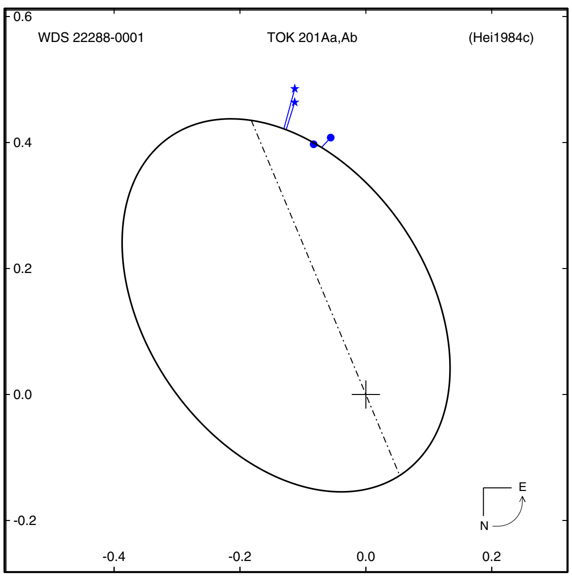

Figure 7. Observed positions of ζ Aqr Aa,Ab with respect to the modified orbit of Heintz (1984b).

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

in the direct shift-and-add (SAA) images after subtracting the rotationally averaged point-spread function (PSF) (Figure 6).

This object was observed again, this time A and B together in a wider 6″ field. In 2010 November the images were AO-corrected. By subtracting a suitably scaled and shifted image of the B component from the image of A, we can see the Ab clearly (Figure 6). The SAA post-processing of the AO-corrected images (selection of 50% sharpest frames and re-centering on maximum intensity) was done to enhance the resolution (before PSF subtraction). The B/A scaling corresponds to $\Delta I = 0.271$ mag. The subsystem Aa,Ab was also detected in the ACFs recorded in December and January (without AO correction). In this case the measurement of Aa,B and Aa,Ab is done by fitting the triple-star model, as in TMH10. Owing to the anisoplanatism, the magnitude difference between A and B is grossly exaggerated in this case.

The companion Ab shows retrograde motion between 2009 and 2010. Its position and displacement are in broad agreement with the astrometric orbit of Heintz (1984b), as noted in SAM10. Three elements of this orbit were modified to fit the data: periastron epoch $T = 2004.0$ (instead of 1981.2), semimajor axis $a = 0\farcs33$, and 180° is added to the position angle of nodes. Figure 7 compares the orbit with measurements.

We conclude that the resolution of the astrometric subsystem in SAM10 was real, but we erroneously attributed it to B, whereas it belongs in fact to A. This confirms the thesis of Heintz (1984b) that all previous resolutions were bogus. See further discussion in SAM10.

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REFERENCES

Alzner, A., & Argyle, R. 2009, Inf. Circ., 169, 1
Alzner, A., Argyle, R., & Anton, R. 2009, Inf. Circ., 169, 1
Andrade, M. 2004, Inf. Circ., 154, 1
Argyle, R. W., & Alzner, A. 2010, Inf. Circ., 170, 1
Baize, P. 1976, A&AS, 26, 177
Baize, P. 1986, A&AS, 65, 551
Baize, P. 1991, A&AS, 87, 49
Balega, I. I., Balega, Y. Y., Hofmann, K.-H., et al. 2005, A&A, 433, 591
Brendley, M., & Hartkopf, W. I. 2006, Inf. Circ., 160, 1
Brendley, M., & Hartkopf, W. I. 2007, Inf. Circ., 163, 1
Carquillat, J.-M., & Prieur, J. L. 2007, Astron. Nachr., 328, 527
Catala, C., Forveille, T., & Lai, O. 2006, AJ, 132, 2318
Costa, J. M. 1975, Inf. Circ., 66, 1
Cvetkovic, Z. 2008a, Inf. Circ., 164
Cvetkovic, Z. 2008b, AJ, 136, 1746
Cvetkovic, Z. 2009, Inf. Circ., 167, 1
Cvetkovic, Z. 2010, Inf. Circ., 170, 1
Cvetkovic, Z. 2011, AJ, 141, 116
Cvetkovic, Z., & Ninkovic, S. 2008, New Astron., 13, 587
Cvetkovic, Z., & Ninkovic, S. 2010, Astron. Nachr., 331, 304

Cvetkovic, Z., & Novakovic, B. 2006, Serb. AJ, 173, 73
Cvetkovic, Z., Novakovic, B., & Todorovic, N. 2008, New Astron., 13, 125
Davis, J., Mendez, A., Seneta, E. B., et al. 2005, MNRAS, 356, 1362
Docobo, J. A. 1991, Inf. Circ., 115, 1
Docobo, J. A., & Andrade, M. 2010, Inf. Circ., 171, 1
Docobo, J. A., & Andrade, M. 2011, Inf. Circ., 174, 1
Docobo, J. A., & Campo, P. 2010, Inf. Circ., 172, 1
Docobo, J. A., & Costa, J. M. 1984, Inf. Circ., 93, 1
Docobo, J. A., & Ling, J. F. 2005, Inf. Circ., 157, 1
Docobo, J. A., & Ling, J. F. 2006, Inf. Circ., 158, 1
Docobo, J. A., & Ling, J. F. 2007, AJ, 133, 1209
Docobo, J. A., & Ling, J. F. 2008, Inf. Circ., 164, 1
Docobo, J. A., & Ling, J. F. 2009a, Inf. Circ., 168, 1
Docobo, J. A., & Ling, J. F. 2009b, AJ, 138, 1159
Docobo, J. A., & Ling, J. F. 2011a, Inf. Circ., 173, 1
Docobo, J. A., & Ling, J. F. 2011b, Inf. Circ., 174, 1
Docobo, J. A., Ling, J. F., & Prieto, C. 1994, ApJS, 91, 793
Docobo, J. A., & Prieto, C. 1991, Inf. Circ., 113, 1
Docobo, J. A., & Prieto, C. 1996, Inf. Circ., 130, 1
Docobo, J. A., Tamazian, V. S., Balega, Y. Y., & Melikian, N. D. 2006, AJ, 132, 994
Finsen, W. S. 1963, Repub. Obs. Circ., 7, 41
Finsen, W. S. 1964, Repub. Obs. Circ., 7, 59
Goldin, A., & Makarov, V. V. 2007, ApJS, 173, 137
Gontcharov, G. A., & Kiyaeva, O. V. 2002, Sov. Astron. Lett., 28, 261
Griffin, R. E. 2005, in Proc. 13th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun, ed. F. Favata, G. A. J. Hussain, & B. Battrick (ESA SP-560; Noordwijk: ESA), 595
Griffin, R. F., & Heintz, W. D. 1987, J. R. Astron. Soc. Can., 81, 3
Hartkopf, W. I. 2000, Inf. Circ., 141, 1
Hartkopf, W. I., & Mason, B. D. 2000, Inf. Circ., 142, 1
Hartkopf, W. I., & Mason, B. D. 2001, Inf. Circ., 143, 1
Hartkopf, W. I., & Mason, B. D. 2009, AJ, 138, 813
Hartkopf, W. I., & Mason, B. D. 2010, Inf. Circ., 170, 1
Hartkopf, W. I., & Mason, B. D. 2011, Inf. Circ., 175
Hartkopf, W. I., Mason, B. D., & McAlister, H. A. 1996, AJ, 111, 370
Hartkopf, W. I., Mason, B. D., & Rafferty, T. 2008, AJ, 135, 1334
Hartkopf, W. I., Mason, B. D., & Worley, C. E. 2001, AJ, 122, 3472 (see the current version at http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/orb6.html)
Hartkopf, W. I., Mason, B. D., Wycoff, G. L., & Kang, D. 2011, Catalog of Rectilinear Elements, http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/lin1.html
Hartkopf, W. I., McAlister, H. A., & Franz, O. G. 1989, AJ, 98, 1014
Heintz, W. D. 1968, AJ, 73, 512
Heintz, W. D. 1978, ApJS, 37, 71
Heintz, W. D. 1979, ApJS, 41, 549
Heintz, W. D. 1981, ApJS, 45, 559
Heintz, W. D. 1984a, AJ, 89, 1063
Heintz, W. D. 1984b, ApJ, 284, 806
Heintz, W. D. 1986, A&AS, 65, 411
Heintz, W. D. 1988, A&AS, 72, 543
Heintz, W. D. 1990, A&AS, 82, 65
Heintz, W. D. 1991, A&AS, 90, 311
Heintz, W. D. 1993, A&AS, 98, 209
Heintz, W. D. 1994, AJ, 108, 2338
Heintz, W. D. 1996, AJ, 111, 412
Heintz, W. D. 1997, ApJS, 111, 335
Heintz, W. D. 1998, ApJS, 117, 587
Honig, S. F., & Tscharnuter, W. M. 2005, AJ, 129, 1663
Hummel, C. A., Carquillat, J.-M., Ginestet, N., et al. 2001, AJ, 121, 1623
Jancart, S., Jorissen, A., Babusiaux, C., & Pourbaix, D. 2005, A&A, 442, 365
Kraus, S., Weigelt, G., Balega, Y. Y., et al. 2009, A&A, 497, 195
Lane, B. F., Muterspaugh, M. W., Fekel, F. C., et al. 2007, ApJ, 669, 1209
Latham, D. W., Stefanik, R. P., Torres, G., et al. 2002, AJ, 124, 1144
Ling, J. F. 2004, ApJS, 153, 545
Ling, J. F. 2010, AJ, 139, 1521
Ling, J. F., & Prieto, C. 1988, Inf. Circ., 105, 1
Ling, J. F., & Prieto, C. 1998, Inf. Circ., 135, 1
Lorenzo, J., Simón-Díaz, S., Negueruela, I., & Vilardell, F. 2010, in ASP Conf. Ser. 435, Binaries—Key to Comprehension of the Universe, ed. A. Prša & M. Zejda (San Francisco, CA: ASP), 409
Makarov, V. V., & Kaplan, G. H. 2005, AJ, 129, 2420
Mante, R. 2001, Inf. Circ., 145, 1
Mante, R. 2003, Inf. Circ., 151, 1
Mason, B. D. 2011, Inf. Circ., 173, 1
Mason, B. D., Douglass, G. G., & Hartkopf, W. I. 1999, AJ, 117, 1023
Mason, B. D., & Hartkopf, W. I. 1999, Inf. Circ., 138, 1
Mason, B. D., & Hartkopf, W. I. 2001, Inf. Circ., 144, 1
Mason, B. D., & Hartkopf, W. I. 2005, Inf. Circ., 156, 1
Mason, B. D., & Hartkopf, W. I. 2010, Inf. Circ., 170, 1
Mason, B. D., & Hartkopf, W. I. 2011a, Inf. Circ., 173, 1
Mason, B. D., & Hartkopf, W. I. 2011b, Inf. Circ., 174, 1
Mason, B. D., Hartkopf, W. I., Gies, D. R., Henry, T. J., & Helsel, J. W. 2009, AJ, 137, 3358
Mason, B. D., Hartkopf, W. I., & Tokovinin, A. 2010, AJ, 140, 735
Mason, B. D., Hartkopf, W. I., Wycoff, G. L., & Holdenried, E. R. 2006, AJ, 132, 2219
Mason, B. D., Hartkopf, W. I., Wycoff, G. L., et al. 2004, AJ, 127, 539
Mason, B. D., Wycoff, G. L., Hartkopf, W. I., Douglass, G. G., & Worley, C. E. 2001, AJ, 122, 3466 (see the current version at http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/wds/wds.html)
Metchev, S., & Hillenbrandt, L. 2009, ApJS, 181, 62
Muterspaugh, M. W., Hartkopf, W. I., Lane, B. F., et al. 2010, AJ, 140, 1623
Nordström, B., Mayor, M., Andersen, J., et al. 2004, A&A, 418, 989
Novakovic, B. 2006, Inf. Circ., 158, 1
Novakovic, B. 2007, Chin. J. Astron. Astrophys., 7, 415
Olevic, D. 2002a, Inf. Circ., 147, 1
Olevic, D. 2002b, Inf. Circ., 148, 1
Olevic, D., & Cvetkovic, Z. 2003a, Inf. Circ., 149, 1
Olevic, D., & Cvetkovic, Z. 2003b, Inf. Circ., 150, 1
Olevic, D., & Cvetkovic, Z. 2004, A&A, 415, 259
Olevic, D., & Cvetkovic, Z. 2005, RevMexA&A, 41, 17
Olevic, D., & Jovanovic, P. 2001, Serb. AJ, 163, 5
Parsons, S. B. 1983, ApJS, 53, 553
Popovic, G. M. 1969, Bull. Obs. Astron. Belgrade, 27, 33
Popovic, G. M. 1978, Bull. Obs. Astron. Belgrade, 129, 9
Popovic, G. M., Pavlovic, R., & Zivkov, V. 1997, Bull. Obs. Astron. Belgrade, 156, 189
Pourbaix, D. 2000, A&AS, 145, 215
Prieur, J.-L., Scardia, M., Pansecchi, L., Argyle, R. W., & Sala, M. 2009, MNRAS, 395, 907
Raghavan, D., McAlister, H. A., Henry, T. J., et al. 2010, ApJS, 190, 1
Ramm, D. J., Pourbaix, D., Hearnshaw, J. B., & Komonjinda, S. 2009, MNRAS, 394, 1695
Rica, F. M. 2010a, Inf. Circ., 171, 1
Rica, F. M. 2010b, Inf. Circ., 172, 1
Rucinski, S. M., Pribulla, T., & van Kerkwijk, M. H. 2007, AJ, 134, 2353
Scardia, M. 1981, Astron. Nachr., 302, 35
Scardia, M. 1983, Astron. Nachr., 304, 257
Scardia, M. 1991, Inf. Circ., 114, 1
Scardia, M. 2001, Inf. Circ., 144, 1
Scardia, M., Prieur, J.-L., Pansecchi, L., & Argyle, R. W. 2008a, Astron. Nachr., 329, 379
Scardia, M., Prieur, J.-L., Pansecchi, L., & Argyle, R. W. 2008b, Inf. Circ., 165, 1
Scardia, M., Prieur, J.-L., Pansecchi, L., & Argyle, R. W. 2008c, Inf. Circ., 166, 1
Scardia, M., Prieur, J.-L., Pansecchi, L., Argyle, R. W., & Sala, M. 2010, Astron. Nachr., 331, 286
Seymour, D., & Hartkopf, W. 1999, Inf. Circ., 139, 1
Seymour, D., Mason, B. D., Hartkopf, W. I., & Wycoff, G. L. 2002, AJ, 123, 1023
Söderhjelm, S. 1999, A&A, 341, 121
Starikova, G. A. 1978, Sov. Astron. Lett., 4, 296
Tokovinin, A., & Cantarutti, R. 2008, PASP, 120, 170
Tokovinin, A., Cantarutti, R., Tighe, R., et al. 2010a, PASP, 122, 1483 (SAM10)
Tokovinin, A., Hartung, M., & Hayward, Th. L. 2010b, AJ, 140, 510
Tokovinin, A. A. 1997, A&AS, 124, 75 (see the current version at http://www.ctio.noao.edu/~atokovin/stars/index.php)
Tokovinin, A. A. 1999, Sov. Astron. Lett., 25, 669
Tokovinin, A. A., Kiyaeva, O., Sterzik, M., et al. 2005, A&A, 441, 695
Tokovinin, A. A., Mason, B. D., & Hartkopf, W. I. 2010c, AJ, 139, 743 (TMH10)
Vogt, S. S., Butler, R. P., Marcy, G. W., et al. 2002, ApJ, 568, 352
Wilson, R. H. 1976, MNRAS, 174, 75P
Worley, C. E. 1981, PASP, 93, 772
Wray, J. D., Parsons, S. B., & Henize, K. G. 1979, ApJ, 234, L187
Zirm, H. 2007, Inf. Circ., 161, 1
Zirm, H. 2008, Inf. Circ., 166, 1
Zirm, H. 2010, Inf. Circ., 172, 1