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# Speckle observations with PISCO in Merate: XII. Astrometric measurements of visual binaries in 2011

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## ABSTRACT

We present relative astrometric measurements of visual binaries, made in 2011 with the speckle camera PISCO at the 102-cm Zeiss telescope of Brera Astronomical Observatory, in Merate. Our observing list contains orbital couples as well as binaries whose motion is still uncertain. We obtained new measurements of 469 objects, with angular separations in the range  $0''.14 - 8''.1$ , and an average accuracy of  $0''.02$ . The mean error on the position angles is  $0^\circ.7$ . Most of the position angles were determined without the usual  $180^\circ$  ambiguity with the application of triple-correlation techniques and/or by inspection of the long integration files. Thanks to a new low magnification option included in PISCO, we have been able to observe fainter stars than previously. The limiting magnitude of our instrumentation on the Zeiss telescope is now close to  $m_V = 10 - 12$ , which permits the observation of some red dwarfs. Finally we present new revised orbits for ADS 8739, 9182 Aa,Ab, 9626 Ba,Bb, 12880, and 14412, partly derived from those observations. The corresponding estimated values for the masses of those systems are compatible with the spectral types.

**Key words:** Stars: binaries: close – binaries: visual — astrometry — techniques: interferometric — stars: individual (ADS 8739, ADS 9182 Aa,Ab, ADS 9626 Ba,Bb, ADS 12880, ADS 14412)

## 1 INTRODUCTION

This paper presents the results of speckle observations of visual binary stars made in Merate (Italy) in 2011 with the Pupil Interferometry Speckle camera and COronagraph (PISCO) on the 102-cm Zeiss telescope of *INAF – Osservatorio Astronomico di Brera* (OAB, Brera Astronomical Observatory). It is the twelfth of a series whose purpose is to contribute to the determination of binary orbits (Scardia et al. 2005, 2006, 2007, 2008a, Prieur et al. 2008, Scardia et al. 2009, Prieur et al., 2009, Scardia et al., 2010, Prieur et al., 2010, Scardia et al., 2011, Prieur et al., 2012, herein: Papers I to XI). The focal instrument PISCO was developed at *Observatoire Midi-Pyrénées* (France) and first used at *Pic du Midi* from 1993 to 1998. It was moved to Merate in 2003 and installed on the INAF Zeiss telescope that has been dedicated to binary star observations since that epoch.

In autumn 2010 and spring 2011, telescope maintenance and several technical tests caused an interruption of the observations. The telescope mirrors were re-aluminized and

some optical tests were done afterwards. We also evaluated a few detectors for PISCO. We ended this “technical break” with a new calibration of PISCO. Despite this interruption, nearly five hundred measurements were made in 2011.

In Sect. 2, we briefly describe our observations. In Sect. 3, we present and discuss the astrometric measurements, and compute O-C residuals for the objects with published orbital elements. Finally in Sect. 4 we propose new revised orbits for ADS 8739, 9182 Aa,Ab, 9626 Ba,Bb, 12880, and 14412, partly derived from those observations, and discuss the estimated values for the masses of those systems.

## 2 OBSERVATIONS

The observations were carried out with the PISCO speckle camera and the ICCD (Intensified Charge Coupled Device) detector belonging to Nice University (France). This instrumentation is presented in Prieur et al. (1998) and our observing procedure is described in detail in Paper VI.

As an attempt to improve the sensitivity of PISCO, some technical tests were done with two ANDOR EMCCD detectors (a LUCA R and an iXon DU885). They were successively installed on PISCO and tested for their performances on binary stars observations. We developed a special program to control those detectors and perform real-time processing. This program has been used in Nice with PISCO2, a simplified version of PISCO (Scardia et al., 2012), since 2009. The effective sensitivity of those detectors for speckle observations was very disappointing. It was found to be much smaller than what could be expected from the quantum efficiency curves of the EMCCD chips. With those two detectors we could not observe fainter stars than what we do with our ICCD detector. As those tests were not conclusive, we decided to continue to use our old ICCD Philips detector.

In 2011, we added a 32 mm eyepiece to our magnification wheel. Since then, PISCO has four magnification options corresponding to the 10, 20, 32 and 50 mm eyepieces. Note that the 50 mm eyepiece is only used for centering the targets. Conversely, the 32 mm eyepiece is a low-magnification option that can be used for speckle measurements. As we will see in the next section, this eyepiece allowed us to observe in 2011 fainter stars than previously.

## 2.1 Observing list

Our observing list basically includes all the visual binaries for which new measurements are needed to improve their orbits, that are accessible with our instrumentation. It consists of a few thousands objects. A detailed description can be found in our previous papers (e.g., Paper VI).

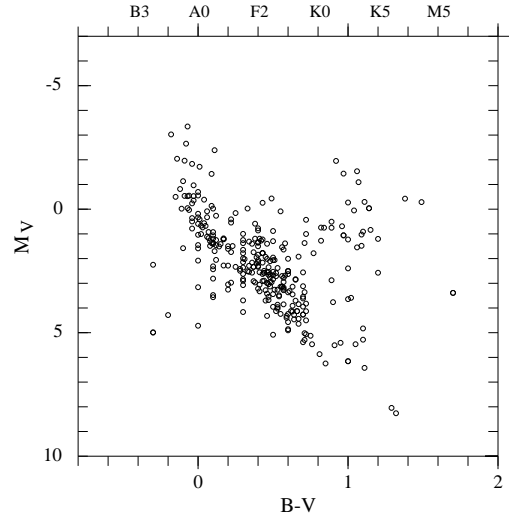
The distribution of the angular separations measured in this paper is displayed in Fig. 1a and shows a maximum for  $\rho \approx 0''.8$ . The largest separation of  $8''.07$  was obtained for ADS 16037AC. The smallest separation was measured for ADS 9301, with  $\rho = 0''.145$ . The diffraction limit is  $\rho_d = \lambda/D \approx 0''.13$  for the Zeiss telescope (aperture  $D = 1.02$  m) and the  $R$  filter ( $\lambda = 650$  nm).

The distribution of the apparent magnitudes  $m_V$  and of the difference of magnitudes  $\Delta m_V$  between the two components are plotted in Figs. 1b and 1c, respectively. The telescope aperture and detector sensitivity led to a limiting magnitude of about  $m_V = 10$  (Fig. 1b) and a maximum  $\Delta m_V$  for speckle measurements of about 3.8 (Fig. 1c).

Using the Hipparcos parallaxes, we were able to construct the HR diagram of those binaries, which is displayed in Fig. 2. We only plotted the objects for which the relative uncertainty on the parallax was smaller than 50%. As mentioned in Sect. 2, we added a 32 mm eyepiece in our filter wheel in 2011. This new low-magnification option enabled the observation of fainter stars than previously. In particular some faint red dwarfs could be observed in 2011. As a result, a larger part of the HR diagram was covered with the observations made in 2011 than with those made previously (e.g., compare Fig 2 with fig. 2 of Paper X).

## 2.2 Calibration of the position angle

In the beginning of 2011, PISCO was dismantled from the telescope for allowing the aluminization of the primary



**Figure 2.** HR diagram of the binaries measured in Table 3, for which Hipparcos parallaxes were obtained with a relative error smaller than 50% (i.e., 311 objects).

and secondary mirrors. After this operation the telescope mirrors were re-aligned and PISCO was re-installed at the Cassegrain focus. A new calibration of the magnification and orientation of PISCO was done in autumn 2011. In this section we describe the position angle calibration. The scale calibration will be presented in the next section (Sect. 2.2).

To calibrate the orientation of the ICCD detector mounted on PISCO, we used the same procedure as in Paper III. Taking advantage of nights with good seeing, we stopped the RA motors and let the target star drift from East to West, while recording long exposures with the lowest magnification (50 mm eyepiece, with a field of view of  $180''$  on a great circle). Using a specially designed program to fit a straight line to the star tracks on the ICCD images, we obtained an accurate value for  $\theta_0$ , the origin of  $\theta$ , the position angle in the celestial reference frame (North corresponding to  $\theta = 0^\circ$ , and East to  $\theta = 90^\circ$ ):

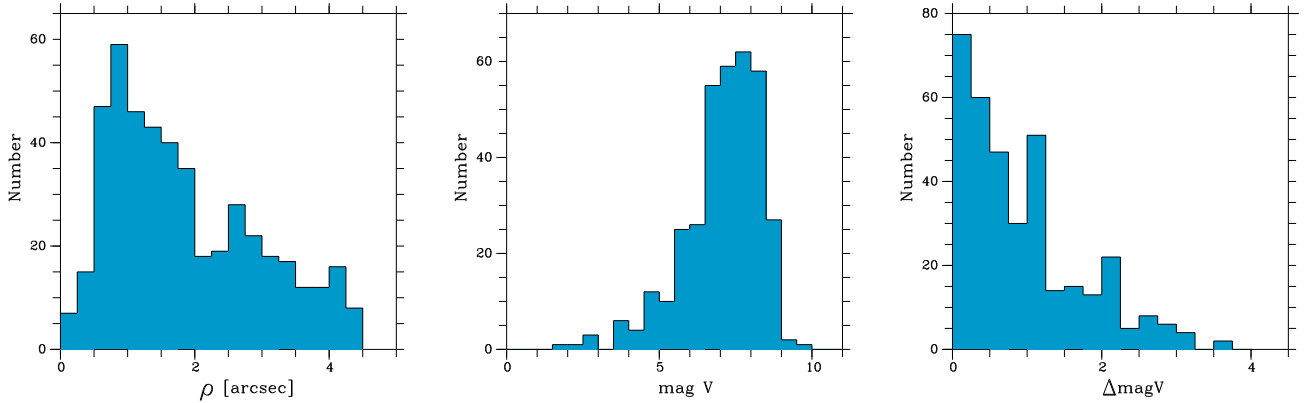
$$\theta = \theta_{\text{detector}} + \theta_0 \quad \text{with} \quad \theta_0 = 89^\circ.94 \pm 0^\circ.11$$

The small value found for the standard deviation confirms the good accuracy of our position angle measurements of binary stars. Note also that this new calibration is very similar to previous calibration of  $\theta_0 = 89^\circ.8 \pm 0^\circ.1$ . Within the (small) uncertainties, we can say that PISCO was mounted in 2011 with the same orientation as in 2003.

## 2.3 Absolute scale calibration with a grating mask

Three eyepieces, of focal lengths 10, 20 and 32 mm, can be used to control the last magnification stage of PISCO for speckle measurements. To calibrate the resulting scales on the detector we have used a grating mask placed at the entrance of the 102-cm Zeiss telescope and followed the procedure described in Paper III.

This mask generated a diffraction fringe pattern whose period is  $p = \lambda/a$  (in radians), where  $\lambda$  is the wavelength of the incoming light (or the “effective wavelength” when using non-monochromatic light) and  $a$  is the grating step



**Figure 1.** Distribution of the angular separations of the 469 measurements of Table 3 (a), the total visual magnitudes of the corresponding binaries (b) and the differences of magnitude between their two components (c).

(i.e. the distance between two successive slits). The measurement  $m$  in pixels of the separation of this “set of artificial binary stars”, whose angular separation is  $p$ , allowed the calibration of the magnification of the whole optical system (telescope+instrument+detector). The scale on the detector is then  $p/m$  in arcsec/pixel. This value was measured on the auto-correlation files obtained when observing Deneb ( $\alpha$  Cyg.) with the grating mask put on top of the telescope on October 10th 2011.

For this scale calibration, we used the  $B$ ,  $V$ ,  $OIII$ ,  $R$  and  $RL$  PISCO filters whose characteristics are given in Table 1. For each filter, the central wavelength  $\lambda_c$  corresponding to the barycenter of the transmission curve is indicated in Col. 3, the width at half maximum  $\Delta_\lambda$  in Col. 4, and the relative transmission  $T$  in Col. 5. The transmission curves were measured with a spectrophotometer in the laboratory. To compute the “effective wavelength”  $\lambda_c^{\text{eff}}$  to be used for the calibration, we multiplied each transmission curve with both the ICCD sensitivity-response and the energy spectral distribution of the astronomical target used for the calibration (i.e. Deneb). The corresponding characteristics of the combination (filter+ICCD+Deneb) are indicated in Table 1 for each filter. The central wavelength  $\lambda_c^{\text{eff}}$  is reported in Col. 6, and the width at half maximum in Col. 7.

The step value of our grating mask is  $a = 87.964$  mm (see paper III). By measuring the mean separation  $m$  of the auto-correlation peaks, we obtained a series of scale values  $\lambda/(am)$  for each different filter. The weighted mean scale values derived from all those measurements are  $32.032 \pm 0.16$ ,  $75.380 \pm 0.50$ , and  $157.859 \pm 1.5$  mas/pixel, for the 10, 20 and 32 mm eyepieces, respectively. Those values are very close to what we obtained in 2005, which were 32.02 and 75.17 mas/pixel, for the 10 and 20 mm eyepieces, respectively.

### 3 ASTROMETRIC MEASUREMENTS

The astrometric measurements obtained with the observations made in 2011 are displayed in Table 3. They concern 469 binaries. For each object, we report its WDS name (Washington Double Star Catalogue, Mason et al. 2013, hereafter WDS Catalogue) in Col. 1, the official double star

**Table 1.** Characteristics of the filters used for the scale calibration (Cols 1 to 5) and effective values when taking into account the ICCD sensitivity and the spectral energy distribution of Deneb (Cols 6 and 7).

Name	Reference	$\lambda_c$ (nm)	$\Delta_\lambda$ (nm)	T (%)	$\lambda_c^{\text{eff}}$ (nm)	$\Delta_\lambda^{\text{eff}}$ (nm)
B	ORIEL/57541	447	47	74	452	44
OIII	ORIEL/54341	501	11	63	501	11
V	ORIEL/57581	530	57	67	530	56
R	ORIEL/57621	644	70	61	641	70
RL	ORIEL/57661	743	69	68	744	63

**Table 2.** Scale values obtained with the filters of Table 1 for three magnifications available with PISCO (eyepieces of 10, 20, and 32 mm).

Eyepiece (mm)	scale (mas/pixel)	error (mas/pixel)
10	32.03	0.16
20	75.38	0.50
32	157.9	1.5

designation in Col. 2 (sequence is “discoverer-number”), and the ADS number in Col. 3 (Aitken, 1932) when available. For each observation, we then give the epoch in Besselian years (Col. 4), the filter (Col. 5), the focal length of the eyepiece used for magnifying the image (Col. 6), the angular separation  $\rho$  (Col. 7) with its error (Col. 8) in arcseconds, and the position angle  $\theta$  (Col. 9) with its error (Col. 10) in degrees. In Col. 11, we report some notes and some information about the secondary peaks of the auto-correlation files (e.g. diffuse, faint or elongated) or about the power spectrum (NF: no fringes). We reported “Bad. id.?” for OL 132, since we probably made a bad identification of this object (see below). For the systems with a known orbit, the ( $O-C$ ) (Observed minus Computed) residuals of the  $\rho$  and  $\theta$  measurements are displayed in Cols. 13 and 14, respectively. The corresponding authors are given in Col. 12, using the bibli-

ographic style of the ‘‘Sixth Catalogue of Orbits of Visual Binary Stars’’ (Hartkopf & Mason, 2013, hereafter OC6). When not explicitly specified, the measurements refer to the AB components of those systems. In Col. 14, the symbol  $Q$  indicates that there was a quadrant inconsistency between our measures and the orbital elements published for this object.

The characteristics of the  $V$ ,  $R$ , and  $RL$  filters used for obtaining those measurements are given in Table 1. Some objects were observed without any filter because they were too faint. This is indicated with  $W$  (for ‘‘white’’ light) in the filter column (Col. 5 of Table 3). In that case, the band-pass and central wavelength correspond to that of the ICCD detector (see Prieur et al., 1998).

As for the other papers of this series, position measurements were obtained by an interactive processing of the auto-correlation files computed in real time during the observations. This processing led to a series of measurements with different background estimates and simulated noise, from which we derived the mean values and the standard deviation of those multiple measurements (see Paper III for more details). The final measures and their errors are displayed in Table 3. The average error values of the measurements reported in this table are  $0''.020 \pm 0''.014$  and  $0^\circ.7 \pm 1^\circ.4$  for  $\rho$  and  $\theta$ , respectively.

There is a possible error of identification of OL 132. The object we observed was very faint (fainter than 12th magnitude) and at the limit of our instrumentation possibilities. We asked R. Gili and J.-C. Thorel to observe OL 132 in Nice (France). With the 76-cm and 50 cm refractors, they did not find any double star at this location or in a circular field of  $9'$  around it. Clearly, C.P. Olivier reported bad coordinates (WDS: 210918.54+143222.6) when he discovered OL 132 in 1932. This naturally explains why Olivier is the unique observer of this object in the WDS. It seems that this binary star was re-discovered by Heintz in 1979 and called Hei 79 (WDS: 210712.71+143434.3). The apparent motion of the companion is very slow, with no detectable variation since 1932. For Hei 79, R. Gili and J.-C. Thorel obtained in 2011 a measurement of ( $\theta = 292^\circ$ ,  $\rho = 1''.7$ ), which corresponds to the measurement of OL 132 given by P. Olivier in 1932, and to that of Hei 79 in 1979. Our measurement ( $\theta = 252^\circ$ ,  $\rho = 1''.6$ ) is different, which indicates that we have probably observed another (unknown) object.

### 3.1 Quadrant determination

As our astrometric measurements were obtained from the *symmetric* auto-correlation files, the  $\theta$  values first presented a  $180^\circ$  ambiguity. To resolve this ambiguity and determine the quadrant containing the companion, we have used Aristidi et al. (1997)’s method. The quadrant were derived from the restricted triple correlation (RTC hereafter) files that were computed in real time during the observations. For the couples with the largest separations, a straightforward determination was done when the companions could be directly spotted on the long integration files.

As a result, in Table 3, we are able to give the unambiguous (i.e. ‘‘absolute’’) position angles of 414 out of 469 measurements, i.e. 88% of the total. They are marked with an asterisk in Col 9. When our quadrant determination procedure failed, the angular measurement was reduced to the

**Table 4.** Objects with discrepant quadrants

Name	Q	Filter	$\Delta m_V$	Spectral type
ADS 10	2	R	0.2	A0
ADS 10905	2	R	0.2	A0
ADS 10945	3	R	0.4	A2
ADS 11558	2	R	0.2	A3
ADS 12895	3	W	0.1	–
ADS 15007	1	R	0.0	F4
ADS 15954	4	R	0.4	O9
ADS 16204	3	R	0.0	G0
ADS 16292	2	R	0.0	F0
ADS 17009BC	2	R	0.1	G
ADS 17122	3	R	0.1	A5

quadrant reported in the WDS catalogue, which is extracted from the Fourth Catalogue of Interferometric Measurements of Binary Stars (Hartkopf et al. 2013, hereafter IC4).

Our ‘‘absolute’’  $\theta$  values are consistent with the values tabulated in WDS for all objects except for ADS 10, 10905, 10945, 11558, 12895, 15007, 15954, 16204, 16292, 17009BC, and 17122 (i.e., 3% of the determinations). We display some information about those objects in Table 4. In Col. 2, we indicate the quadrant (Q) that was obtained with the RTC, using the usual convention of numbering it from 1 to 4 to indicate the North-East, South-East, South-West and North-West quadrants, respectively. In Col. 3 we indicate which filter we have used ( $W$  indicates the absence of filter; the corresponding central wavelength is close that of the  $R$  filter). We report the difference of magnitude between the two components from the IC4 in Col. 4, and the global spectral type found in the SIMBAD astronomical data base in Col. 5.

For all those objects, the small value of  $\Delta m_V$  can account for the difficulty of measuring the quadrant for those binaries. Moreover, most of the measurements from other observers reported in IC4 were all obtained in  $V$ , whereas we observed in  $R$  or in  $W$  (which is similar to  $R$ ). A quadrant inversion between  $V$  and  $R$  is thus likely, when the two stars have a different spectral type (e.g. blue primary and red secondary).

### 3.2 Comparison with published ephemerides

The ( $O - C$ ) (Observed minus Computed) residuals of the measurements for the 112 systems with a known orbit in Table 3 are displayed in Cols. 13 and 14 for the separation  $\rho$  and position angle  $\theta$ , respectively.

Those residuals were obtained with a selection of valid orbits found in the OC6 catalogue. We did not always use the most recent orbits since sometimes older orbits led to equivalent or even smaller residuals.

For ADS 8739, 9182 Aa,Ab, 9626 Ba,Bb, 12880, and 14412, we also reported the residuals obtained with some revised orbits presented in Sect. 4.

Fig. 3 shows that the residuals have a rather large scatter. This scatter can be explained by the (old) age of many orbits. The mean values computed with the residuals of Table 3 are  $\langle \Delta \rho_{O-C} \rangle = -0''.001 \pm 0''.078$  and  $\langle \Delta \theta_{O-C} \rangle = -0^\circ.10 \pm 1^\circ.52$ . The small values obtained for those offsets provide a good validation of our calibration (see Sects. 2.2 and 2.3).

**Table 3.** Table of speckle measurements and O-C residuals with published orbits (begin.)

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	$\rho$ (")	$\sigma_\rho$ (")	$\theta$ ( $^\circ$ )	$\sigma_\theta$ ( $^\circ$ )	Notes	Orbit	$\Delta\rho(\text{O-C})$ (")	$\Delta\theta(\text{O-C})$ ( $^\circ$ )
00029+4715	A800	10	2011.907	R	32	1.580	0.016	112.6*	0.4				
00048+4358	A203	39	2011.969	R	32	1.834	0.032	347.4*	1.2				
11037+6145	BU1077	8035	2011.411	V	10	0.637	0.003	10.3*	0.4		Sca2011a	0.00	-1.6
12329+5448	A1600	8594	2011.411	R	32	0.882	0.017	9.5	1.9				
12417-0127	STF1670	8630	2011.408	R	20	1.675	0.017	16.6	0.4		Sca2007c	0.01	-0.1
12417-0127	STF1670	8630	2011.469	R	20	1.670	0.008	16.0	0.3		Sca2007c	-0.01	-0.5
12438+0733	STF1674	8646	2011.408	R	32	2.313	0.017	173.5	0.4				
12533+1310	HU894	8696	2011.408	R	32	1.190	0.019	145.2	0.9				
12574+3022	STF1696	8716	2011.411	R	32	3.667	0.038	203.7	0.3				
13007+5622	BU1082	8739	2011.408	R	20	0.991	0.011	105.5*	0.6		Sca2005a	-0.16	4.5
"	"	"	"	"	"	"	"	"	"		This paper	-0.08	1.2
13100+1732	STF1728	8804	2011.488	R	10	0.594	0.003	11.5	0.4	Elong.	Pal2005b	-0.01	-0.3 <sup>Q</sup>
13120+3205	STT261	8814	2011.488	R	32	2.555	0.016	338.8*	0.3				
13166+5034	STT263	8843	2011.411	R	32	1.719	0.019	135.8*	0.9				
13235+2914	HO260	8887	2011.411	R	32	1.577	0.021	86.1*	0.5		WSI2004a	-0.07	1.2
13284+1543	STT266	8914	2011.477	R	32	1.943	0.016	357.2*	0.4		Hrt2011d	-0.06	0.2
13343-0019	STF1757	8949	2011.477	R	32	1.763	0.019	135.2*	0.3		Hei1988d	-0.05	-0.2
13346+3308	BU933	8958	2011.411	R	32	2.738	0.019	22.2*	0.3				
13356+4939	AG190	8964	2011.409	R	32	2.609	0.043	12.1	0.3				
13377+5043	STF1770	8979	2011.477	R	32	1.713	0.017	120.3*	0.4				
13431+0332	STF1777	9000	2011.491	RL	32	2.744	0.025	226.3*	0.5	NF			
13461+0507	STF1781	9019	2011.469	R	20	0.937	0.008	191.4*	0.7		Alz2007	0.00	-0.2
13491+2659	STF1785	9031	2011.469	R	32	3.057	0.016	181.8*	0.3		Hei1988d	0.01	-0.6
13563+0517	STT273	9060	2011.491	R	32	0.945	0.024	111.2*	1.0				
13571+3426	BU937	9067	2011.469	R	32	1.025	0.016	135.3*	0.8				
13577+5200	A1614	9071	2011.477	R	32	1.365	0.024	299.2	0.9		Hei2001	-0.10	-3.3 <sup>Q</sup>
13598+1953	STF1794	9078	2011.409	R	32	1.882	0.049	125.5*	0.4				
14101+2636	STF1808	9136	2011.409	R	32	2.598	0.016	81.1*	0.3				
14116+2802	STF1810	9150	2011.409	R	32	2.307	0.016	183.4*	0.8				
14131+5520	STF1820	9167	2011.477	R	32	2.699	0.024	119.8*	0.3		Kiy1998	0.06	-1.5
14135+1234	BU224	9165	2011.491	W	20	0.567	0.027	103.1*	0.6		Lin1985c	-0.03	1.4
14138+1200	STT279	9168	2011.491	R	20	2.199	0.013	254.9*	0.3	NF			
14139+2906	STF1816	9174	2011.496	R	20	0.409	0.008	96.0*	0.6				
14148+1006	KUI66	-	2011.496	RL	20	0.995	0.008	107.9*	0.4	NF, faint			
14153+0308	STF1819Aa,Ab	9182	2011.477	W	20	0.893	0.008	174.5*	0.9		Hou1987	0.02	-1.4
"	"	"	"	"	"	"	"	"	"		This paper	-0.00	-0.6
14203+4830	STF1834	9229	2011.477	R	32	1.624	0.022	101.8*	0.3		USN2000c	0.07	-1.8
14234+4736	A149	9249	2011.477	W	20	0.779	0.008	123.8*	0.5				
14301+0617	STF1853	9287	2011.480	R	32	2.855	0.028	81.5*	0.6				
14323+2641	A570	9301	2011.504	R	10	0.145	0.018	6.5	2.1		Hei1991	-0.03	1.4
14336+3535	STF1858	9312	2011.496	R	32	3.029	0.016	37.5*	0.3				
14339+5514	STF1860	9315	2011.477	R	32	0.992	0.103	112.3*	1.8				
14369+4813	A347	9324	2011.488	R	20	0.561	0.008	241.8*	0.9	Elong.	Doc2004a	-0.01	-0.9
14380+5135	STF1863	9329	2011.488	R	20	0.665	0.008	60.2*	0.7	Elong.			
14416+5124	STF1871	9350	2011.496	R	32	1.820	0.017	310.2	0.3				
14426+1929	HU575	9352	2011.504	W	20	0.547	0.024	152.4*	1.8		Sod1999	0.00	1.4
14428+0635	A1109	9353	2011.480	RL	32	1.830	0.024	84.8*	0.3		WSI2006b	0.12	-2.9
14450+2704	STF1877	9372	2011.496	RL	32	2.827	0.019	343.4*	0.3	Faint			
14455+4223	STT285	9378	2011.485	R	20	0.477	0.009	85.8	0.6		Cou1973b	-0.02	-1.0
14463+0939	STF1879	9380	2011.469	R	32	1.713	0.017	82.6*	0.3		Msn1999a	-0.01	-1.1
14471+0058	STF1881	9383	2011.501	RL	32	3.440	0.022	0.3*	0.3	NF			
14484+2422	STF1884	9389	2011.502	R	32	2.171	0.016	54.7*	0.5				
14489+0557	STF1883	9392	2011.469	R	20	0.960	0.008	278.4	0.3		USN2000c	0.00	0.5
14489+0557	STF1883	9392	2011.485	R	20	0.963	0.008	278.6	0.3		USN2000c	0.01	0.7
14497+0759	A1110	9400	2011.504	R	20	0.682	0.008	244.0*	1.0				
14497+4843	STF1890	9406	2011.485	R	32	2.669	0.016	44.8*	0.3				

**Table 3.** Table of speckle measurements and O-C residuals with published orbits (cont.)

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	$\rho$ (")	$\sigma_\rho$ (")	$\theta$ ( $^\circ$ )	$\sigma_\theta$ ( $^\circ$ )	Notes	Orbit	$\Delta\rho(\text{O-C})$ (")	$\Delta\theta(\text{O-C})$ ( $^\circ$ )
14506-0001	STF1885	9407	2011.504	R	32	4.045	0.020	144.4*	0.3				
14515+4456	STT287	9418	2011.485	R	20	0.675	0.011	359.2	0.5		Hei1997	-0.09	0.6
14524+1757	A2071	9422	2011.499	W	32	1.381	0.025	269.5*	1.5				
14534+1542	STT288	9425	2011.477	R	20	1.067	0.008	160.1*	0.4		Hei1998	0.01	-0.5
14536-0028	BU942	9426	2011.504	W	32	1.419	0.036	185.2	0.4				
14584+1508	OL187	-	2011.499	W	32	1.708	0.024	78.6*	0.8				
15126+1523	STF1917	9533	2011.485	R	32	2.519	0.016	232.9*	0.3				
15173+0923	A1117	9568	2011.485	R	32	0.965	0.021	358.2*	0.8				
15208+4242	A573	9603	2011.499	W	20	0.731	0.009	171.6*	1.1	Diffuse			
15245+3723	STF1938Ba,Bb	9626	2011.499	R	32	2.255	0.016	5.4*	0.3		Sca1986b	0.03	0.5
"	"	"	"	"	"	"	"	"	"		Sod1999	0.01	0.7
"	"	"	"	"	"	"	"	"	"		This paper	0.03	0.5
15348+1032	STF1954	9701	2011.499	R	32	3.986	0.020	172.2*	0.3		WSI2004a	0.00	-0.2
15360+3948	STT298	9716	2011.499	R	20	1.119	0.008	180.4*	0.3		Cou1989c	-0.02	0.4
15361+4849	HU652	9718	2011.504	R	32	1.120	0.016	185.1*	0.8				
15382+3615	HU1167AB	9731	2011.491	R	32	1.367	0.051	79.7*	1.1		Dru1995	0.12	-1.3
15382+3615	STF1964CD	9731	2011.491	R	32	1.564	0.030	19.3*	0.5		Dru1995	0.04	0.1
15396+7959	STF1989	9769	2011.504	R	20	0.666	0.008	22.8*	0.4		Sca2003a	-0.04	0.4
15413+5959	STF1969	9756	2011.504	R	32	1.006	0.021	28.0*	1.0		Hei1975b	0.09	-0.7
15568+1229	STF1988	9850	2011.586	R	32	1.850	0.016	249.1*	0.3				
16003+5856	STF2006	9891	2011.491	W	32	1.482	0.030	178.2*	1.2				
16009+1316	STT303	9880	2011.586	R	32	1.555	0.016	172.5*	0.6				
16030+1359	STF2000	9904	2011.586	R	32	2.585	0.016	226.0*	0.3				
16089+4521	STF2015	9940	2011.505	R	32	2.958	0.016	158.7*	0.3				
16122-0007	A2179	9955	2011.608	R	20	0.793	0.037	76.7*	0.9	NF			
16133+1332	STF2021	9969	2011.592	R	32	4.059	0.020	356.5*	0.3		Hop1964b	-0.02	1.0
16137+4638	A1642	9975	2011.592	R	20	0.783	0.011	182.1*	0.6		Hrt2001b	0.03	0.7
16145+0531	STF2023	9974	2011.592	R	32	1.947	0.017	223.4*	0.3				
16153+0416	STF2027	9980	2011.592	R	32	1.871	0.016	79.9*	0.3				
16238+6142	STF2054	10052	2011.641	R	20	0.967	0.010	350.4*	0.3				
16279+2559	STF2049	10070	2011.641	R	20	1.133	0.011	194.5*	0.3				
16280+2632	BU813	10071	2011.592	R	32	1.168	0.047	176.1*	1.0				
16282+6041	COP3	10080	2011.586	R	32	1.349	0.019	87.8*	0.6				
16289+1825	STF2052	10075	2011.505	R	32	2.269	0.016	119.0*	0.3		Lmp2001a	0.01	-0.6
16309+0159	STF2055	10087	2011.592	R	20	1.408	0.008	38.4*	0.3		Hei1993b	-0.04	0.1
16316+5746	YNG1	10109	2011.633	R	32	1.269	0.021	215.0*	0.7				
16326+2314	BU817	10107	2011.641	R	32	0.920	0.030	328.9*	1.5				
16326+4007	STT313	10111	2011.633	R	20	0.921	0.014	130.3*	0.6				
16362+5255	STF2078	10129	2011.641	R	32	3.139	0.017	103.8*	0.4				
16413+3136	STF2084	10157	2011.586	RL	20	1.123	0.008	162.6*	0.3		Hei1994a	-0.05	-0.1
16438+5133	HU664	10189	2011.627	R	20	0.494	0.014	302.6*	1.0				
16442+2331	STF2094	10184	2011.592	R	20	1.162	0.008	72.3*	0.3				
16514+0113	STT315	10230	2011.638	R	20	0.679	0.008	311.6*	0.7		Doc2007d	-0.01	-0.2
16518+2840	STF2107	10235	2011.592	R	20	1.433	0.008	102.2*	0.3		Sca2003c	0.04	-1.1
16564+6502	STF2118	10279	2011.586	R	20	1.028	0.008	65.5*	0.3		Sca2002d	-0.13	-1.5
16588+0358	STF3107	10285	2011.633	R	32	1.401	0.030	69.2*	0.7				
17020+0827	STF2114	10312	2011.608	R	20	1.329	0.008	195.2*	0.3				
17053+5428	STF2130	10345	2011.586	R	20	2.439	0.012	6.3*	0.3		Pru2012	0.01	0.0
17066+0039	BU823	10341	2011.608	R	32	0.988	0.016	164.8*	1.3		Hrt2000c	-0.01	-3.0
17131+5408	STF2146	10410	2011.608	RL	32	2.665	0.022	224.0*	0.4				
17195+5832	KR46	10487	2011.608	R	32	1.710	0.016	63.4*	0.3				
17222+2605	HO414	10504	2011.627	W	20	0.780	0.008	104.0*	0.4	Elong.			
17231+2545	HO415	10514	2011.608	W	20	0.900	0.008	343.6*	0.3				
17237+3709	STF2161	10526	2011.608	R	32	4.013	0.020	319.4*	0.3				
17238+2155	HU671	10521	2011.627	W	20	0.861	0.009	262.3*	0.3				
17239+3627	STF2162	10527	2011.608	R	32	1.304	0.022	283.8*	0.4				

**Table 3.** Table of speckle measurements and O-C residuals with published orbits (cont.)

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	$\rho$ (")	$\sigma_\rho$ (")	$\theta$ ( $^\circ$ )	$\sigma_\theta$ ( $^\circ$ )	Notes	Orbit	$\Delta\rho(\text{O-C})$ (")	$\Delta\theta(\text{O-C})$ ( $^\circ$ )
17240-0050	STF2156	10518	2011.638	R	32	3.828	0.019	35.8*	0.3				
17268+2240	J1032	10557	2011.628	W	32	4.007	0.020	350.0*	0.3				
17304-0104	STF2173	10598	2011.633	R	20	0.820	0.008	151.5*	0.3		Hei1994a	-0.01	-0.8
17317+1111	AG354	10612	2011.636	R	32	2.490	0.025	51.2*	0.6				
17320+0249	STT331	10614	2011.638	R	32	1.000	0.022	351.1*	0.6				
17344+4913	HU923	10646	2011.636	R	32	0.991	0.036	105.0*	1.2				
17358+0100	STF2186	10650	2011.636	R	32	3.024	0.016	77.1*	0.3	Elong.			
17386+5546	STF2199	10699	2011.636	R	32	2.059	0.016	55.3*	0.3		Pop1995d	0.13	1.7
17397+7256	H 1 41	10734	2011.636	R	20	0.991	0.008	335.4*	0.4				
17403+6341	STF2218	10728	2011.636	R	20	1.475	0.008	310.3*	0.3				
17406+2017	AG211	10711	2011.636	W	32	2.648	0.016	127.9*	0.4				
17412+4139	STF2203	10722	2011.647	R	20	0.743	0.008	292.6	0.4				
17434+3357	HO560	10742	2011.647	R	32	1.310	0.024	262.4*	0.7				
17439+0551	STF2200	10741	2011.647	R	32	1.545	0.016	162.1*	0.3				
17445+1900	STF2206	10756	2011.636	R	32	1.025	0.054	248.6	1.7				
17457+1743	STF2205	10769	2011.647	R	32	0.972	0.021	4.9	1.2		Cve2008a	-0.07	0.7
17464+0542	STF2212	10779	2011.649	W	32	3.200	0.019	340.8*	0.3				
17471+1742	STF2215	10795	2011.649	R	10	0.485	0.003	252.5	0.5		Cve2006e	0.02	2.2
17506+0714	STT337	10828	2011.660	R	20	0.561	0.017	164.5*	1.7	NF, faint	Doc1990a	0.05	-0.1
17511+5523	HO71	10854	2011.641	W	32	3.751	0.043	226.7*	1.1	NF			
17520+1520	STT338	10850	2011.641	R	20	0.824	0.008	164.5*	0.4		Pru2012	-0.00	-0.4
17533+3605	STF2243	10874	2011.641	R	32	1.111	0.016	38.7*	0.8				
17541+2949	AC9	10880	2011.647	R	32	1.098	0.024	240.1	0.6				
17564+1820	STF2245	10905	2011.649	R	32	2.598	0.016	110.1*	0.3				
17571+0004	STF2244	10912	2011.647	R	20	0.651	0.008	99.6*	0.5		Hei1997	0.12	-1.0
17571+4551	HU235	10934	2011.649	RL	32	1.556	0.028	282.5*	1.1				
17590+0202	STF2252	10945	2011.660	R	32	3.969	0.020	203.6*	0.3				
17590+1226	STF2254	10949	2011.660	R	32	3.498	0.025	265.4*	0.3				
18003+5251	STF2271	10988	2011.628	R	32	3.399	0.017	266.9*	0.3				
18017+4011	STF2267	11001	2011.660	R	20	0.541	0.014	271.5*	1.0				
18025+4414	BU1127	11010	2011.628	R	20	0.722	0.008	50.4*	0.7		Cve2006e	-0.08	-1.9
18065+4022	STF2282	11074	2011.647	R	32	2.643	0.016	81.2*	0.3	Diffuse			
18070+3034	AC15	11077	2011.660	RL	20	1.175	0.008	316.7*	0.5		Sod1999	0.00	1.3
18093+1329	STF2285	11108	2011.682	W	32	3.525	0.030	331.9*	0.5	Diffuse			
18093+1329	STF2285	11108	2011.726	R	32	3.558	0.019	331.4*	0.4				
18096+0400	STF2281	11111	2011.671	R	20	0.657	0.013	287.0*	0.6		Sod1999	-0.01	1.3
18096+0609	STF2283	11110	2011.671	R	20	0.595	0.008	53.7*	0.5				
18097+5024	HU674	11128	2011.671	R	20	0.734	0.011	212.2*	0.6		USN2002	0.17	-0.2
18101+1629	STF2289	11123	2011.587	R	20	1.217	0.008	218.6*	0.4		Hop1964b	-0.02	2.4
18113+1713	HU317	11141	2011.701	R	32	1.463	0.016	202.7*	0.3				
18126+3836	BU1091	11170	2011.628	W	20	0.736	0.011	319.0*	0.7		Sca2012	-0.01	-1.2
18126+3836	BU1091	11170	2011.737	R	20	0.747	0.008	319.2*	0.5		Sca2012	0.00	-1.0
18126+3836	BU1091	11170	2011.742	R	20	0.752	0.010	319.1*	0.6		Sca2012	0.01	-1.1
18126+4123	STF2298	11174	2011.682	R	32	1.845	0.016	174.6*	0.6				
18128+0549	STT345	11160	2011.701	R	32	1.477	0.016	66.2*	0.6				
18146+0011	STF2294	11186	2011.660	R	32	1.334	0.036	92.6*	0.4		Luy1934a	0.13	-0.5
18200+2120	AG221	11265	2011.663	R	32	1.659	0.022	12.3*	0.4				
18201+2532	STF2309	11267	2011.663	R	32	3.587	0.018	350.9*	0.5				
18208+7120	STT353	11311	2011.690	R	10	0.502	0.003	265.7*	0.3		Ana2005	-0.00	-1.2
18212+2820	STF2312	11280	2011.663	R	32	1.621	0.017	340.0*	1.0				
18218+2130	BU641	11287	2011.671	R	20	0.757	0.010	342.3*	0.8				
18222+1413	AG222	11291	2011.663	R	32	1.413	0.019	145.8*	0.5				
18238+5139	ES187	11328	2011.660	R	32	2.567	0.016	206.1*	0.3				
18239+5848	STF2323	11336	2011.628	RL	32	3.727	0.019	348.3*	0.3		Nov2006e	-0.02	-0.1

**Table 3.** Table of speckle measurements and O-C residuals with published orbits (cont.)

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	$\rho$ (")	$\sigma_\rho$ (")	$\theta$ ( $^\circ$ )	$\sigma_\theta$ ( $^\circ$ )	Notes	Orbit	$\Delta\rho(\text{O-C})$ (")	$\Delta\theta(\text{O-C})$ ( $^\circ$ )
18250-0135	AC11	11324	2011.671	R	20	0.891	0.008	355.0*	0.5		Hei1995	0.07	0.5
18250+2724	STF2315	11334	2011.587	R	20	0.636	0.008	118.4*	1.0		WSI2004b	0.01	0.0
18253+4653	BU134	11343	2011.663	RL	32	1.076	0.036	125.8*	1.0				
18253+4846	HU66AB	11344	2011.690	R	20	0.213	0.008	35.9	0.6		USN2002	0.05	3.5 <sup>Q</sup>
18253+4846	STT351AC	11344	2011.690	R	20	0.772	0.008	25.1*	0.3				
18253+4846	HU66BC	11344	2011.690	R	20	0.982	0.008	27.4*	0.3		Nov2008b	0.08	0.6
18261+0047	BU1203	11339	2011.690	R	20	0.498	0.008	156.1*	0.7		Pop1996b	0.01	-0.0
18269+0625	STT350	11349	2011.663	RL	32	1.809	0.016	166.4*	0.8				
18272+0012	STF2316Aa-B	11353	2011.698	R	32	3.700	0.030	319.9*	0.8				
18276+0633	BU464	11366	2011.704	R	32	0.997	0.016	103.3*	0.7				
18278+2442	STF2320	11373	2011.737	R	20	1.119	0.011	358.3*	1.1				
18295+2955	STF2328	11397	2011.737	R	32	3.764	0.019	71.0*	0.6				
18310+0123	STF2324	11410	2011.742	R	32	2.359	0.032	147.0*	0.4	Faint			
18314+0628	STF2329	11420	2011.737	R	32	4.313	0.022	42.8*	0.3				
18320+0647	STT354	11432	2011.660	R	20	0.567	0.009	211.6	1.7				
18338+1744	WAK21CD	11454	2011.698	R	20	0.443	0.011	262.0*	1.3				
18338+1744	STF2339AB-D	11454	2011.698	R	20	2.013	0.010	273.2*	0.3				
18338+1744	STF2339AB-C	11454	2011.698	R	20	1.581	0.008	276.3*	0.3				
18339+5221	A1377	11468	2011.690	R	10	0.241	0.005	127.2*	0.5	Elong.	Mut2010e	-0.01	0.2
18355+2336	STT359	11479	2011.608	R	20	0.735	0.008	4.6*	0.3		Sca2009a	-0.01	-0.1
18359+1659	STT358	11483	2011.608	R	20	1.654	0.008	149.7*	0.3		Hei1995	0.13	1.4
18360+1144	STT357	11484	2011.690	R	20	0.388	0.014	76.4	0.3		Sca2011a	0.01	1.3
18374+7741	STT363	11584	2011.742	R	20	0.523	0.013	337.9	0.4		Sca2009a	0.05	-3.0
18384+0850	HU198	11524	2011.698	R	10	0.515	0.005	127.2*	0.5	Diffuse	Nov2007d	0.06	-2.1
18384+2842	STF2356	11529	2011.609	R	32	1.098	0.017	63.2*	1.2				
18384+3603	STF2362	11534	2011.609	R	32	4.326	0.022	186.7*	0.3				
18387+0451	STT360	11526	2011.690	RL	20	1.706	0.009	281.5*	0.3				
18389+5221	STF2368	11558	2011.641	R	32	1.833	0.016	139.3*	0.4				
18393+2056	STF2360	11546	2011.636	R	32	2.424	0.016	358.3*	0.3				
18410+0302	BU1328	11569	2011.704	R	32	2.073	0.016	281.7*	0.4				
18413+3018	STF2367	11579	2011.690	R	20	0.401	0.008	74.5*	0.9		Pbx2000b	-0.01	0.5
18443+3940	STF2382AB	11635	2011.592	R	20	2.322	0.012	347.0*	0.3		WSI2004b	-0.05	0.0
18443+3940	STF2383CD	11635	2011.592	R	20	2.384	0.012	77.7*	0.3		Doc1984b	0.01	0.2
18443+6103	STF2403	11661	2011.698	R	20	1.039	0.009	278.0*	0.6				
18443+6103	STF2403	11661	2011.704	R	20	1.061	0.014	277.9*	0.3				
18455+0530	STF2375	11640	2011.698	R	20	2.569	0.013	119.6*	0.3				
18458+3431	STF2390	11669	2011.728	R	32	4.162	0.043	154.8*	0.3				
18469+5920	STF2410	11697	2011.682	R	32	1.680	0.027	85.5*	0.3				
18472+3125	STF2397	11685	2011.729	R	32	3.874	0.028	265.8*	0.5				
18477+4904	HEI72	-	2011.761	R	20	0.636	0.008	235.9*	0.4				
18487+3401	HU936	11717	2011.671	R	32	1.828	0.017	97.8*	0.4				
18490+2110	STF2401	11715	2011.663	R	32	4.269	0.021	37.6*	0.3	NF			
18497+1041	STF2402	11722	2011.636	R	32	1.427	0.016	207.8	0.8				
18502+1131	BU265	11735	2011.699	R	20	1.397	0.008	228.2*	0.6	Faint			
18508+1059	STF2404	11750	2011.663	R	32	3.523	0.018	180.9*	0.3				
18517+1331	STF2409	11763	2011.707	R	20	0.996	0.017	20.3*	0.8				
18517+4323	BU421	11775	2011.671	R	32	1.182	0.016	293.8	0.4				
18520+1047	STF2408	11766	2011.663	R	32	2.256	0.016	90.6*	0.3				
18521+1148	HU199	11769	2011.699	R	32	0.864	0.025	346.2	1.1	Faint			
18526+1400	STF2412	11778	2011.682	R	32	1.422	0.024	55.6*	0.5				
18540+3723	BU137	11811	2011.726	R	32	1.507	0.016	163.3*	0.6				
18545+2037	STF2415	11816	2011.742	R	32	1.961	0.016	288.9*	0.5				
18549+3358	STT525	11834	2011.748	RL	20	1.791	0.013	129.1*	0.4	NF			
18555+2914	STF2419	11847	2011.682	R	32	3.345	0.022	177.7*	0.6				

**Table 3.** Table of speckle measurements and O-C residuals with published orbits (cont.)

WDS	Name	ADS	Epoch	Fil.	Eyep.	$\rho$	$\sigma_\rho$	$\theta$	$\sigma_\theta$	Notes	Orbit	$\Delta\rho(\text{O-C})$	$\Delta\theta(\text{O-C})$
					(mm)	( $''$ )	( $''$ )	( $^\circ$ )	( $^\circ$ )			( $''$ )	( $^\circ$ )
18559+0323	A2193	11844	2011.748	R	32	0.877	0.016	354.8	1.4				
18570+3254	BU648	11871	2011.699	RL	20	1.151	0.008	251.2*	0.4		Mut2010e	-0.00	-0.6
18571+2606	STF2422	11869	2011.699	R	20	0.767	0.011	70.1	1.0				
18575+5814	STF2438	11897	2011.660	R	20	0.859	0.009	357.9*	0.3		Hrt2001a	0.03	0.2
18581+4711	AG366	11899	2011.660	R	32	1.431	0.016	188.7*	0.5				
18594+2936	STF2430	11914	2011.682	R	32	1.488	0.016	187.4*	0.4				
19008+2318	HJ2850	11934	2011.671	W	32	2.590	0.074	273.6*	0.3	Elong.			
19019+1910	STF2437	11956	2011.701	R	20	0.575	0.008	7.2*	0.3		Sca2008c	0.01	-0.5
19024+6927	STF2478	12015	2011.699	R	32	0.907	0.022	316.0	0.7				
19030+5135	STF2451	11997	2011.682	R	32	1.898	0.030	82.1*	0.4				
19030+5135	STF2451	11997	2011.729	R	32	2.014	0.022	80.9	0.9	Faint			
19052+1050	BU466	12021	2011.761	R	32	1.915	0.024	164.9*	0.6				
19062+3026	STF2454	12040	2011.701	R	32	1.316	0.016	288.4*	0.9		Baz1976	-0.00	0.5
19070+1104	HEI568	-	2011.761	R	10	0.292	0.004	265.9*	0.4	Elong.			
19071+7204	STT369	12113	2011.701	R	20	0.697	0.008	9.7*	0.3				
19079+2948	STF2466	12071	2011.729	R	32	2.378	0.016	102.9*	0.8	Faint			
19079+2948	STF2466	12071	2011.761	R	32	2.381	0.016	102.2*	0.3				
19083+5520	D19	12104	2011.701	R	20	0.483	0.008	348.1*	1.1				
19114+2116	A151	12140	2011.701	W	20	0.621	0.010	157.5*	0.7	Elong.			
19143+1904	STF2484	12201	2011.701	R	32	2.098	0.017	239.5*	0.4		Hop1973b	-0.17	0.3
19159+2727	STT371	12239	2011.682	R	20	0.882	0.008	160.0*	0.3				
19162+2817	STF2491	12246	2011.756	R	32	1.291	0.021	228.9*	0.3				
19169+6312	STF2509	12296	2011.707	R	32	1.830	0.016	328.3*	0.4				
19185+0105	STF2492	12289	2011.707	RL	20	3.232	0.016	2.1*	0.4	Faint			
19185+0105	STF2492	12289	2011.707	R	20	3.232	0.017	2.1*	0.3	Faint			
19185+0620	BU1256	12288	2011.756	R	32	1.566	0.016	42.5*	0.7				
19186+2157	STF2499	12298	2011.726	R	32	2.594	0.016	323.5*	0.3				
19213+5549	STF2516	12363	2011.756	R	32	4.154	0.021	233.4*	0.3				
19222+1640	HO105	12358	2011.756	R	32	2.789	0.021	188.1*	0.4				
19266+2719	STF2525	12447	2011.663	R	20	2.161	0.011	289.2	0.3		Hei1984b	0.04	-0.6
19299+4931	BU143	12535	2011.699	R	32	2.163	0.017	191.9*	0.3	Faint			
19334+6203	STF2553	12626	2011.707	R	20	0.996	0.008	129.6*	0.8				
19346+1808	STT375	12623	2011.701	R	20	0.603	0.008	185.8*	0.3				
19363+3540	STT377	12667	2011.737	R	32	0.920	0.017	33.3	0.5				
19365+4101	STT378	12687	2011.701	R	32	1.338	0.032	284.7*	0.5				
19438+3819	STT384	12851	2011.761	R	32	1.033	0.016	195.6*	0.6				
19448+1649	STF2569	12861	2011.737	R	32	2.068	0.017	355.3*	0.7				
19450+4508	STF2579	12880	2011.690	RL	20	2.694	0.013	218.2*	0.3		Sca1983a	0.00	-0.9
"	"	"	"	"	"	"	"	"	"		This paper	-0.00	-0.4
19453+3048	AG237	12881	2011.737	R	32	2.425	0.016	140.7*	0.4				
19463+1035	BU55	12895	2011.726	W	32	2.003	0.025	191.2*	0.3				
19464+3344	STF2576	12889	2011.682	R	32	2.928	0.021	157.9*	0.4		Lmp2001a	0.00	0.1
19464+3344	STF2576	12889	2011.690	R	32	2.921	0.016	158.0*	0.3		Lmp2001a	-0.00	0.2
19468+1733	HU345	12915	2011.753	R	32	3.811	0.021	101.8*	0.3				
19482+7016	STF2603	13007	2011.832	RL	20	3.180	0.016	20.0*	0.3				
19483+3710	STT386	12965	2011.748	R	32	0.907	0.019	70.2	1.0				
19484+2212	STF2584	12957	2011.737	R	32	1.935	0.016	292.7	0.5				
19486+2458	STF2586	12964	2011.737	R	32	3.781	0.025	225.6*	0.3				
19487+1149	STF2583	12962	2011.737	R	20	1.437	0.011	105.1*	0.3				
19487+3519	STT387	12972	2011.690	R	20	0.520	0.008	117.7*	0.8		WSI2006b	-0.00	-1.8
19489+3202	A375	12978	2011.753	R	32	1.177	0.016	158.8*	1.1				
19492+1428	AG392	12976	2011.753	R	32	3.476	0.017	151.8*	0.6	Diffuse			
19503+2240	BU361	13005	2011.753	R	32	3.721	0.024	347.5*	0.3	Diffuse			
19516+2009	HU350	13031	2011.753	R	32	3.389	0.017	45.3*	0.5	Diffuse			
19524+2551	STT388	13050	2011.690	R	32	3.884	0.019	137.2*	0.3				

**Table 3.** Table of speckle measurements and O-C residuals with published orbits (cont.)

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	$\rho$ (")	$\sigma_\rho$ (")	$\theta$ ( $^\circ$ )	$\sigma_\theta$ ( $^\circ$ )	Notes	Orbit	$\Delta\rho(\text{O-C})$ (")	$\Delta\theta(\text{O-C})$ (")
19535+2405	DJU4	–	2011.753	R	20	1.385	0.008	244.8*	0.3		Cve2008d	0.05	–1.6
19540+1518	STF2596	13082	2011.690	R	32	2.018	0.028	298.3*	0.5				
19552+2230	STF2600	13119	2011.753	R	32	3.116	0.035	54.1*	0.3				
19556+5226	STF2605	13148	2011.762	R	32	2.866	0.016	175.3*	0.3				
19575+2018	BU425	13165	2011.704	R	32	1.354	0.016	239.8	0.6				
19586+3806	STF2609	13198	2011.737	R	32	1.905	0.025	22.2*	0.5				
19591+3532	STF2610	13204	2011.737	R	32	4.288	0.021	295.0*	0.3				
20011+4816	STF2619	13269	2011.704	R	32	4.135	0.027	239.1*	0.3				
"	"	"	2011.759	R	32	4.179	0.021	238.7*	0.3				
20014+1045	STF2613	13256	2011.704	R	32	3.580	0.018	354.5*	0.3		Hop1973b	–0.58	2.6
20016+7027	A865	13315	2011.832	R	32	2.609	0.016	87.5*	0.3				
20017–0012	H193	13259	2011.756	R	32	1.801	0.016	296.5*	0.5				
20017+5806	AG395	13297	2011.833	R	32	4.239	0.021	357.3*	0.4				
20020+2456	STT395	13277	2011.704	R	32	1.657	0.024	125.0*	0.4				
20021+5439	BU426AB	13301	2011.833	R	32	5.729	0.029	305.5*	0.3	NF			
20021+5439	BU426CD	13301	2011.833	R	32	3.097	0.016	336.2*	0.3				
20025+3940	BRT2251	–	2011.759	W	32	4.252	0.027	153.7*	0.4	NF			
20035+3601	STF2624Aa-B	13312	2011.748	R	32	1.934	0.016	173.8*	0.3				
20042+1148	STF2620	13320	2011.704	R	32	1.808	0.017	286.2*	0.3				
20072+2106	STF2631	13393	2011.759	R	32	4.544	0.023	338.2*	0.3				
20078+0924	STF2628	13403	2011.756	R	32	2.964	0.017	338.0*	0.3				
20095+5140	STF2645	13447	2011.748	R	32	1.545	0.044	135.6*	0.5				
20096+1648	STF2634	13434	2011.759	R	32	4.119	0.021	14.3*	0.3				
20096+3325	HJ1485	13441	2011.759	R	32	4.712	0.024	275.5*	0.3				
20102+4357	STT400	13461	2011.756	R	20	0.630	0.008	333.5*	0.6		Hei1997	0.00	0.8
20106+3338	STT541BC	13463	2011.759	R	32	1.695	0.017	182.3*	1.3	Diffuse			
20106+3452	A281	13465	2011.756	R	32	4.111	0.021	171.9*	0.3				
20126+0052	STF2644	13506	2011.748	R	32	2.624	0.016	206.2*	0.5				
20128–0300	STF2643	13511	2011.860	RL	32	3.065	0.040	79.3*	0.3				
20137+1609	STF2651	13542	2011.748	R	32	0.940	0.030	277.6	0.4				
20137+2414	STF2653	13543	2011.756	RL	32	2.831	0.022	274.2*	0.3				
20144+4206	STT403	13572	2011.756	R	20	0.948	0.008	170.2*	0.5				
20153+2536	BU983	13589	2011.868	RL	10	0.470	0.004	185.4*	1.0	NF			
20168–0329	RST4659	–	2011.860	RL	32	1.691	0.066	7.3*	0.7				
20181+4044	STF2666	13672	2011.756	RL	32	2.751	0.016	244.6*	0.3				
20184+5524	STF2671	13692	2011.762	R	32	3.675	0.018	336.5*	0.3				
20198+4522	STT406	13723	2011.868	R	10	0.318	0.009	99.6	1.1		Hei1976	–0.06	–2.4
20203+3924	STF2668AB-C	13728	2011.860	RL	32	3.388	0.051	279.2*	0.5				
20227+1320	STF2673	13767	2011.759	W	32	2.299	0.016	326.1*	0.6				
20244+2923	HO457	13818	2011.865	R	32	2.062	0.046	60.8*	1.1				
20248+3545	BU432	13830	2011.860	R	32	1.384	0.017	196.8*	0.6				
20255+4006	D22	13847	2011.860	R	32	2.885	0.016	162.2*	0.5				
20293+3731	WEI35	13909	2011.865	R	32	4.130	0.033	213.0*	0.3				
20356+3510	STF2702	14045	2011.865	R	32	3.133	0.017	204.8*	0.6				
20375+1436	BU151	14073	2011.868	R	10	0.214	0.008	47.7*	1.4	Elong.	Sod1999	–0.02	–1.5
20377+3322	STF2705	14078	2011.865	R	32	3.130	0.041	261.5*	0.3				
20396+3030	STF2711	14124	2011.868	R	32	2.403	0.025	222.7*	0.7				
20396+4035	STT410	14126	2011.865	R	20	0.865	0.010	4.0	0.6		Hrt2011a	–0.00	–0.0
20423+5723	BU152	14196	2011.748	R	32	1.131	0.017	83.0*	0.7				
20435+1657	STF2720	14206	2011.868	R	32	3.830	0.054	178.1*	0.3				
20448+2825	AG411	14241	2011.876	R	32	2.890	0.016	20.5*	0.8				
20449+1219	STF2723	14233	2011.748	R	20	1.031	0.008	136.4*	0.6				
20450+1244	BU64	14238	2011.887	W	20	0.675	0.010	353.2	0.7	Elong.	USN2007a	0.02	–1.0
20474+3629	STT413Aa-B	14296	2011.887	R	20	0.909	0.011	4.5*	0.4		Sta1982b	–0.04	0.8

**Table 3.** Table of speckle measurements and O-C residuals with published orbits (cont.)

WDS	Name	ADS	Epoch	Fil.	Eyep.	$\rho$	$\sigma_\rho$	$\theta$	$\sigma_\theta$	Notes	Orbit	$\Delta\rho(\text{O-C})$	$\Delta\theta(\text{O-C})$
					(mm)	( $''$ )	( $''$ )	( $^\circ$ )	( $^\circ$ )			( $''$ )	( $^\circ$ )
20487+5155	STF2732	14336	2011.873	R	32	4.253	0.076	71.4*	0.4				
20490+3947	STF2731	14334	2011.873	R	32	4.151	0.027	85.4*	0.4				
20511+5125	BU155	14370	2011.874	R	20	0.739	0.008	38.5*	0.5				
20514-0538	STF2729	14360	2011.895	R	20	0.818	0.019	27.2*	0.5	Elong.	Hei1998	0.07	-1.0
20531+2909	STT417	14397	2011.874	R	20	0.900	0.027	25.9*	2.0				
20537+5918	A751	14412	2011.895	R	10	0.195	0.010	52.4	2.6		Hrt1989	0.01	-5.2
"	"	"	"	"	"	"	"	"	"		This paper	0.01	-3.4
20541+4507	STT422	14411	2011.874	R	32	2.582	0.016	332.6*	0.6				
20547+3704	STT419	14420	2011.879	RL	20	1.703	0.011	24.5*	0.3				
20548+3242	STT418	14421	2011.748	R	32	0.924	0.016	282.7	1.1				
20553+4231	STT423	14432	2011.876	RL	32	2.768	0.049	75.9*	0.7				
20557+0432	STF2735	14430	2011.876	RL	20	2.029	0.010	281.1*	0.3				
20576+4058	A400	14475	2011.879	W	32	1.422	0.088	68.1*	0.9				
20576+6121	STF3133	14495	2011.874	R	32	3.272	0.035	99.9*	1.0				
20577+5849	A756	14493	2011.895	R	20	0.567	0.019	209.6	2.9				
20585+5028	STF2741	14504	2011.874	R	20	1.962	0.012	24.4*	0.3				
20591+0418	STF2737	14499	2011.876	R	10	0.458	0.008	283.9	0.3	Elong.			
21008+4635	BU156	14561	2011.895	R	20	1.050	0.015	236.4*	0.5				
21018+3916	STF2746	14558	2011.737	R	20	1.212	0.010	321.5*	0.4				
21021+5640	STF2751	14575	2011.879	R	20	1.615	0.011	355.4*	0.4				
21022+0711	STF2742	14556	2011.753	R	32	2.895	0.016	213.7*	0.3				
21024+3739	STF2747	14569	2011.882	R	32	4.672	0.023	265.3*	0.3				
21031+0132	STF2744	14573	2011.753	R	20	1.266	0.009	111.6*	0.3		Pop1969b	0.06	5.4
21045+0746	BU269	14600	2011.898	RL	32	1.164	0.038	238.4*	1.8				
21046+5224	STF2757	14615	2011.754	R	32	1.850	0.017	262.3*	0.5				
21047+0332	STF2749AB	14602	2011.898	R	32	3.057	0.016	180.3*	0.3				
21047+0332	STF2749AC	14602	2011.898	R	32	3.455	0.038	172.2*	0.3				
21068+3408	STF2760	14645	2011.754	R	32	4.806	0.024	32.4*	0.3				
21070+5900	STF2766	14669	2011.882	R	32	4.554	0.023	247.7*	0.3				
21086+3012	STF2762	14682	2011.901	R	32	3.342	0.030	302.6*	0.3				
21093+3131	COU1333	-	2011.896	R	20	0.704	0.021	250.6	1.2				
21097+1434	OL132	-	2011.906	W	32	1.612	0.016	251.9*	1.4	Bad. id.?			
21105+4742	BU159	14720	2011.882	RL	20	1.200	0.015	311.6*	0.7				
21109+0352	HO151	14712	2011.906	R	32	1.340	0.035	15.8*	1.0				
21110+0933	STF2765	14715	2011.876	R	32	2.842	0.049	78.2*	1.0				
21112+5620	DOO16	14739	2011.882	R	32	1.101	0.017	28.5*	0.7				
21115+4115	STT431	14733	2011.876	R	32	2.601	0.021	123.9*	0.4				
21118+5959	STF2780Aa-B	14749	2011.887	R	20	1.030	0.011	213.1*	0.5				
21120+2410	STT430	14738	2011.906	R	32	1.417	0.017	191.7*	1.0				
21137+6424	H148	14783	2011.887	R	20	0.520	0.010	241.3*	0.6		Sca2008a	-0.10	-1.0
21141+5818	STF2783	14784	2011.887	R	20	0.703	0.008	352.3*	1.7				
21143+4109	STT432	14778	2011.887	R	20	1.315	0.008	114.8*	0.4				
21145+1000	STT535	14773	2011.901	R	10	0.271	0.008	25.6*	1.2	Elong.	Mut2008	-0.02	-1.1 <sup>Q</sup>
"	"	"	"	"	"	"	"	"	"		Sod1999	-0.01	-1.4 <sup>Q</sup>
"	"	"	"	"	"	"	"	"	"		Sod1999	0.01	0.4
21148+3803	AGC13	14787	2011.906	RL	10	0.826	0.006	222.2*	0.3				
21160+1600	HO284	14797	2011.898	R	32	3.871	0.019	86.5*	0.8	Diffuse			
21171+3546	BU162	14822	2011.887	R	32	1.198	0.025	253.7*	0.8				
21176+8231	STF2807	14921	2011.901	R	32	1.757	0.051	307.4*	0.5	Elong.			
21177+3345	HO153	14829	2011.887	W	20	0.911	0.017	127.6*	1.1				
21185+8021	STF2801	14916	2011.901	R	32	2.089	0.030	269.5*	0.7	Diffuse			
21197+0931	STF2786	14856	2011.865	R	32	2.727	0.019	188.6*	0.4				
21197+3315	HO155	14861	2011.907	R	32	2.040	0.022	36.7*	0.3				
21208+3227	STT437	14889	2011.860	R	32	2.441	0.016	19.9*	0.8		Hrt2011a	0.03	0.6
21213+6042	STF2795	14912	2011.901	R	32	1.716	0.070	301.7*	1.7				
21230+3202	HO157	14928	2011.860	R	32	3.558	0.021	26.3*	0.6				
21237+0422	STF2791	14933	2011.898	R	32	2.869	0.041	103.8*	0.9				

**Table 3.** Table of speckle measurements and O-C residuals with published orbits (cont.)

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	$\rho$ (")	$\sigma_\rho$ (")	$\theta$ ( $^\circ$ )	$\sigma_\theta$ ( $^\circ$ )	Notes	Orbit	$\Delta\rho(\text{O-C})$ (")	$\Delta\theta(\text{O-C})$ ( $^\circ$ )
21252+3129	A1220	14957	2011.898	R	32	1.537	0.016	160.2*	1.6				
21280+4305	HO160	15000	2011.901	R	32	1.980	0.041	181.5*	0.8				
21289+1105	STF2799	15007	2011.756	R	32	1.861	0.016	79.5*	0.4		Hrt2011a	0.00	-0.0 <sup>Q</sup>
21330+2043	STF2804	15076	2011.756	R	32	3.321	0.017	357.3*	0.3				
21441+2845	STF2822	15270	2011.756	R	20	1.707	0.009	314.6*	0.3		Hei1995	0.09	-3.3
21446+2539	BU989	15281	2011.871	R	10	0.210	0.003	281.4*	0.4	Elong.	Sod1999	-0.00	-1.0 <sup>Q</sup>
"	"	"	"	"	"	"	"	"	"		Mut2008	0.00	0.5 <sup>Q</sup>
21454+4356	HO168	15295	2011.868	R	32	0.863	0.016	220.6	1.9				
21480+6920	STF2835	15350	2011.871	R	32	1.768	0.047	269.7*	0.7				
21510+6137	STT451	15390	2011.866	R	32	4.147	0.021	218.1*	0.3				
21516+6545	STF2843	15407	2011.866	R	32	1.324	0.021	149.7*	0.5				
21555+1053	BU75	15447	2011.868	R	20	0.984	0.009	23.3*	0.5		Hei1996a	-0.02	0.0
21555+5232	STT456	15460	2011.866	R	32	1.539	0.016	35.6*	0.9				
21555+6519	STT457	15467	2011.871	R	20	1.298	0.009	245.3*	0.7				
21565+5948	STT458	15481	2011.868	R	20	0.957	0.009	347.7*	1.3				
22009+6250	HU976	15558	2011.868	R	32	1.540	0.017	57.1*	1.3				
22029+4439	BU694	15578	2011.969	R	20	0.974	0.011	6.5*	0.8				
22044+1339	STF2854	15596	2011.866	R	32	1.623	0.017	82.9*	0.7				
22058+0452	STF2856	15614	2011.898	R	32	1.194	0.017	192.9*	0.7				
22071+0034	STF2862	15639	2011.898	R	32	2.468	0.040	95.1*	0.3				
22086+5917	STF2872BC	15670	2011.871	R	20	0.831	0.008	297.5	0.3		USN2002	0.02	-0.2
22100+2308	COU136	-	2011.871	R	20	0.474	0.013	21.6	1.0		Cou1999b	-0.05	-0.6
22118+5944	STF2880	15729	2011.896	R	32	4.250	0.100	352.4*	0.4				
22122+6344	STF2884	15742	2011.969	R	32	2.089	0.040	143.1*	0.5	Diffuse			
22126+3013	HO179	15738	2011.896	R	20	0.887	0.014	282.1*	1.3				
22128+1355	HU978	15735	2011.833	R	32	1.258	0.038	205.7*	0.9	NF			
22141+3123	BU476	15761	2011.882	R	32	2.790	0.016	92.4*	0.3				
22145+0759	STF2878	15767	2011.871	R	20	1.485	0.008	115.5*	0.3				
22146+2934	STF2881	15769	2011.759	R	32	1.277	0.017	75.4*	0.4				
22148+2157	AG281	15772	2011.896	R	32	2.615	0.043	19.4*	0.5				
22206+5349	BU379	15856	2011.860	R	32	1.071	0.019	333.7*	0.7				
22218+6642	STF2903	15881	2011.969	RL	32	4.143	0.051	95.4*	0.4	Diffuse			
22222+5959	A629	15885	2011.882	R	32	1.217	0.041	342.4*	1.8				
22269+6343	KR59	15954	2011.969	R	32	1.717	0.021	345.2*	1.5				
22272+1509	STF2905	15950	2011.871	R	32	3.327	0.032	283.5	0.3				
22288-0001	STF2909	15971	2011.759	R	20	2.193	0.011	167.4*	0.3		Sca2010c	0.02	-1.6
22302+2228	HU388	15992	2011.907	R	20	0.648	0.038	60.1	2.1		Doc2008c	0.12	0.2
22312+5052	STF2918	16020	2011.860	R	32	1.561	0.033	236.5*	0.5				
22323+5512	AG283	16032	2011.860	R	32	2.662	0.028	330.8*	0.4				
22328+2625	HO475AB	16037	2011.887	R	32	1.081	0.017	305.5	1.0				
22328+2625	HO475AC	16037	2011.887	R	32	8.074	0.117	223.7*	0.5	Diffuse			
22349+4134	HJ1788	16084	2011.759	R	32	3.655	0.027	298.4*	0.3				
22395+3653	HJ968	16150	2011.860	R	32	4.315	0.046	109.2*	0.3				
22419+2126	STF2934	16185	2011.860	R	32	1.405	0.016	57.7*	0.9		Hei1981a	0.18	1.8
22426+4401	A414	16204	2011.887	R	32	1.656	0.043	193.0*	1.8				
22441+3928	STF2942	16228	2011.860	RL	20	2.852	0.014	277.7*	0.3	NF			
22496+6633	STF2948	16298	2011.874	R	32	2.653	0.016	4.4*	0.5				
22497+3119	STF2945	16292	2011.860	R	32	4.195	0.035	117.7*	0.3				
22507+5107	HLD54	16307	2011.868	R	32	1.803	0.016	16.4*	0.8				
22514+2623	HO482	16314	2011.907	R	20	0.509	0.008	17.4*	0.9		Sca2012	-0.02	0.3
22514+6142	STF2950	16317	2011.868	R	20	1.217	0.015	276.3*	0.3				
22537+4445	BU382	16345	2011.907	R	20	0.777	0.017	237.3*	0.3		Sod1999	-0.02	1.7
22542+7620	STF2963	16371	2011.877	R	32	1.853	0.027	2.2*	0.6				
22562+7250	STF2965DE	16384	2011.877	R	32	2.852	0.016	219.5*	0.9				
22565+6252	STF2961	16394	2011.868	R	32	1.853	0.016	347.4*	0.3				

**Table 3.** Table of speckle measurements and O-C residuals with published orbits (cont.)

WDS	Name	ADS	Epoch	Fil.	Eyep.	$\rho$	$\sigma_\rho$	$\theta$	$\sigma_\theta$	Notes	Orbit	$\Delta\rho(\text{O-C})$	$\Delta\theta(\text{O-C})$
					(mm)	( $''$ )	( $''$ )	( $^\circ$ )	( $^\circ$ )			( $''$ )	( $^\circ$ )
22597+4149	HLD56	16435	2011.860	R	32	1.142	0.022	91.1*	0.6				
23007+3105	STF2968	16443	2011.877	RL	32	3.184	0.016	92.6*	0.7				
23010+2646	STF2969	16449	2011.879	R	32	3.991	0.044	35.6*	0.6				
23050+3322	STF2974	16496	2011.860	R	32	2.664	0.027	164.9*	0.5				
23072+6050	BU180	16518	2011.879	R	20	0.537	0.010	134.3*	0.9		Lin2010c	0.01	0.3
23078+3947	STF2979	16527	2011.898	R	32	2.819	0.016	227.5*	0.3				
23078+6338	HU994	16530	2011.896	R	10	0.211	0.010	315.6	2.7		Doc1991e	-0.04	2.6
23083+3028	HO196	16531	2011.898	R	32	1.845	0.017	295.2*	1.1				
23102+5727	STT490	16560	2011.907	RL	20	1.185	0.008	296.6*	0.4				
23103+3229	BU385	16561	2011.868	R	20	0.633	0.009	85.4*	0.8		Lin2010c	-0.04	0.3
23162+5424	A1482	16641	2011.879	R	32	1.299	0.016	87.6*	0.6				
23186+6807	STF3001	16666	2011.879	R	32	3.345	0.047	221.7*	0.4		Doc2003d	-0.00	-0.4
23188+2513	STF3000	16664	2011.879	R	32	3.406	0.035	49.8*	0.4				
23208+2158	STT494	16686	2011.871	R	32	3.282	0.040	81.0*	0.5				
23276+1638	STF3012AB	16766	2011.879	R	32	2.828	0.016	190.1*	0.6				
23276+1638	STF3013CD	16766	2011.879	R	32	3.218	0.028	276.1*	0.3				
23277+7406	STF3017	16775	2011.907	R	20	1.254	0.008	20.7*	0.4				
23280+3333	STF3015	16774	2011.888	R	32	2.902	0.019	189.6*	0.6				
23292+4042	A1487	16785	2011.888	R	32	1.057	0.024	158.9*	1.7				
23324+1724	STF3023	16821	2011.871	R	20	1.758	0.017	279.6*	0.6				
23326+3127	WNC6	16822	2011.882	R	32	1.594	0.024	154.6*	1.3				
23340+3120	BU720	16836	2011.896	R	10	0.565	0.009	101.7*	0.5	Elong.	Mut2010e	-0.00	-0.3
23363+2854	STF3026	16860	2011.899	R	32	3.244	0.022	273.7*	0.3				
23413+3234	BU858	16928	2011.888	R	32	0.836	0.016	220.4	1.9				
23420+2018	STT503	16937	2011.871	R	32	0.970	0.024	133.0*	0.6				
23461+6028	STF3037	16982	2011.874	RL	32	2.590	0.028	210.8*	0.7				
23479+1703	STF3041BC	17009	2011.877	R	32	3.413	0.046	176.4*	0.3				
23487+6453	STT507	17020	2011.896	R	20	0.723	0.014	319.2*	1.7		Zul1977b	0.01	2.7
23488+6213	STT508	17022	2011.907	RL	20	1.488	0.032	194.7*	0.6				
23516+4205	STT510	17050	2011.888	R	20	0.593	0.011	119.0	0.7		Nov2006e	0.00	-1.6 <sup>Q</sup>
23522+4331	BU728	17063	2011.877	R	32	1.202	0.017	10.2*	1.5				
23576+4804	A799	17122	2011.877	R	32	1.978	0.044	190.5*	1.3				
23584+3501	STT513	17136	2011.896	RL	32	3.267	0.054	17.0*	0.3				
23590+5315	HLD59	17141	2011.907	R	20	1.195	0.009	12.1*	0.5				
23590+5545	STF3049	17140	2011.874	RL	32	3.094	0.030	325.4*	0.5				
23592+7448	BU1154	17143	2011.907	R	20	1.246	0.008	331.3*	0.9				
23595+3343	STF3050	17149	2011.874	R	20	2.282	0.011	337.0*	0.3		Hrt2011a	-0.02	-0.5

Note: In column 9, the exponent \* indicates that the position angle  $\theta$  could be determined without the 180° ambiguity. In column 14, the exponent Q indicates discrepant quadrants between our measurements and the published orbits.

In the following, we examine the cases of ADS 8739, 13256, 14412 and 14573, that appear with large residuals in Fig. 3.

**ADS 8739:** this couple has a large magnitude difference ( $\Delta m_V = 2.86$ ) which makes it difficult to observe. The orbit we computed in 2005 shows rather large residuals with our measurement of 2011. We propose a new orbit in Sect. 4.1.

**ADS 13256:** this object has the largest residual in Table 3 of ( $\Delta\rho = -0''.581$ ,  $\Delta\theta = 2^\circ.6$ ) with Hopmann (1973)'s orbit. This orbit was computed a long time ago, with insufficient data. The arc of the monitored orbit was very short in 1973, but has not increased very much since. It cannot be excluded that the motion is rectilinear.

**ADS 14412:** the residuals are rather large with Hartkopf et al (1989)'s orbit. We present a new orbit in Sect. 4.5.

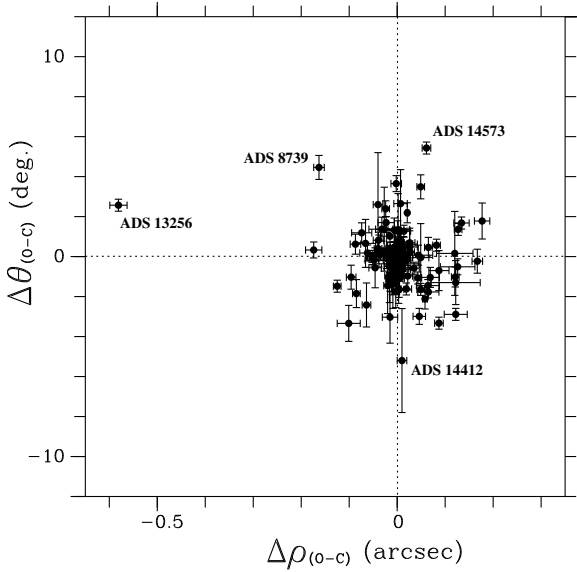
**ADS 14573:** the residuals are rather large with the orbit of Popovic (1969). This can be easily explained because Popovic's orbit was very premature. More than forty years

later, the monitored arc of orbit is still too small to allow a good orbit determination.

#### 4 REVISED ORBITS OF ADS 8739, 9182 AA,AB, 9626 BA,BB, 12880, AND 14412

In this section we present the new revised orbits we have computed for ADS 8739, 9182 Aa,Ab, 9626 Ba,Bb, 12880, and 14412.

We have followed the same method for those five objects. Using our last measurements with PISCO and the other available observations contained in the data base maintained by the United States Naval Observatory (USNO), we first computed the preliminary orbital elements with the analytical method of Kowalsky (1873). We then used them as initial values for the least-squares method of Hellerich (1925). When convergence was achieved, Hel-



**Figure 3.** Residuals of the measurements of Table 1 computed with the published orbits.

lerich’s method led to an improvement of the orbital elements (with the exception of the major axis) and to an estimation of the corresponding errors. The final value of the major axis was then set to the value that minimized the residuals in separation of Hellerich’s solution.

The final orbital elements are presented in Table 5. The errors reported in this table were obtained by Hellerich’s least-squares method. The description of the format of the tables contained in this section can be found in Papers VI and VII.

The ( $O-C$ ) residuals of the new orbits, restricted to the last observations for reasons of space, are given in Tables 6, 7, 8, 9, and 10, for ADS 8739, 9182 Aa,Ab, 9626 Ba,Bb, 12880, and 14412, respectively. The name of the observer is reported in the last column, using the US Naval Observatory convention.

The ephemerides for 2013–2022 are presented in Table 11. The apparent orbits are shown in Fig. 4 as solid lines. The observational data used for the calculation of the orbital elements are plotted as small crosses or, in the case of PISCO observations, as filled circles. The orientation of the graphs conforms to the convention adopted by the observers of visual binary stars. For each object, the location of the primary component is indicated with a big cross. The straight line going through this point is the line of apsides. An arrow shows the sense of rotation of the companion.

In Table 12, we present some physical parameters of those systems. The visual magnitudes (Col. 3), the difference of magnitude between the components (Col. 4) and the spectral types (Col. 5) were extracted from the IC4 and the SIMBAD data bases. The dynamical parallaxes are presented in Col. 6. Except for ADS 12880 which is a giant star, (see Sec. 4.4), those parallaxes were derived from our orbital elements using Baize & Romani (1946)’s method. In Col. 7, we report either the Hipparcos parallaxes from ESA (1997) or the revised values from van Leeuwen (2007), as indicated in Col. 11. In Cols. 8, 9 and 10, we give the

**Table 6.** ADS 8739: O-C residuals of our new orbit (after 2008). The symbol  $P$  indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) (")	$\Delta\theta$ (O-C) ( $^{\circ}$ )	Observer
2008.311	-0.063	3.8	Ant
2008.490	-0.045 $P$	-0.5 $P$	Pru
2009.244	-0.021	0.2	Ant
2009.380	-0.108	-0.2	Los
2009.382	-0.048 $P$	-0.3 $P$	Sca
2010.185	-0.086	-4.4	Los
2010.324	-0.042 $P$	0.3 $P$	Pru
2011.408	-0.076 $P$	1.2 $P$	This paper
2012.356	-0.059 $P$	2.3 $P$	Sca
2012.413	-0.051 $P$	0.9 $P$	Sca

**Table 7.** ADS 9182 Aa,Ab: O-C residuals of our new orbit (after 2007). The symbol  $P$  indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) (")	$\Delta\theta$ (O-C) ( $^{\circ}$ )	Observer
2007.314	0.005	0.2	Hrt
2007.444	-0.025	0.3	WSI
2008.490	-0.021 $P$	0.8 $P$	Pru
2009.263	0.015	-0.4	Tok
2009.263	0.013	-0.3	Tok
2010.396	-0.023	2.1	Los
2010.591	-0.047	1.3	Msn
2011.477	-0.001 $P$	-0.6 $P$	This paper
2012.460	-0.012 $P$	0.1 $P$	Sca

corresponding angular and linear sizes of  $a$  and  $\mathfrak{M}_{\text{total}}$ , respectively, that were computed from our orbital elements and the Hipparcos parallaxes.

#### 4.1 New orbit of ADS 8739

##### WDS 13007+5622 – BU 1082 – ADS 8739 (HIP 63503):

This couple was discovered by S.W. Burnham on Feb. 21st 1889 with the 91-cm refractor of Lick Observatory

**Table 8.** ADS 9626 Ba,Bb: O-C residuals of our new orbit (after 2009). The symbol  $P$  indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) (")	$\Delta\theta$ (O-C) ( $^{\circ}$ )	Observer
2009.299	0.021	-0.3	Ant
2009.376	0.061	0.8	Ary
2009.391	0.047 $P$	0.3 $P$	Sca
2009.514	-0.029	0.5	Bvd
2010.390	0.053	0.6	Los
2010.419	0.053	1.3	Ant
2010.468	-0.057	0.1	WSI
2010.538	0.042 $P$	0.3 $P$	Pru
2011.499	0.029 $P$	0.5 $P$	This paper
2011.609	0.215	0.6	Ary
2012.457	0.047 $P$	0.2 $P$	Sca

**Table 5.** New orbital elements of ADS 8739, 9182 Aa,Ab, 9626 Ba,Bb, and 12880.

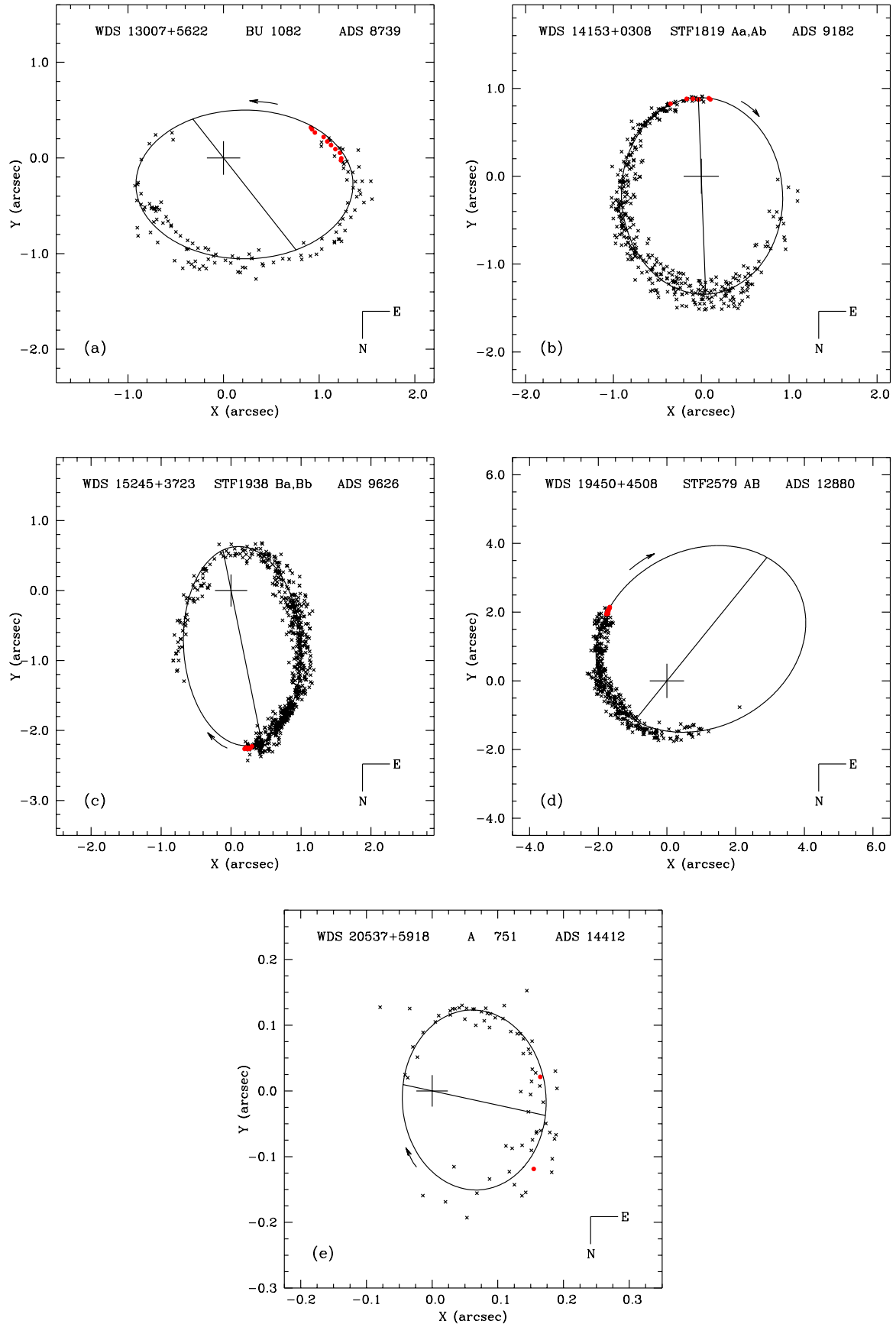
ADS	$\Omega_{2000}$ ( $^{\circ}$ )	$\omega$ ( $^{\circ}$ )	$i$ ( $^{\circ}$ )	$e$	$T$ (yr)	$P$ (yr)	$n$ ( $^{\circ}$ /yr)	$a$ ( $''$ )	A ( $''$ )	B ( $''$ )	F ( $''$ )	G ( $''$ )
8739	94.8 $\pm 1.3$	113.18 $\pm 0.99$	49.60 $\pm 0.86$	0.4051 $\pm 0.0076$	1921.529 $\pm 0.32$	105.06 $\pm 0.50$	3.4266 $\pm 0.016$	1.220 $\pm 0.042$	-0.68414	-0.53936	0.40399	-1.09154
9182 Aa,Ab	3.0 $\pm 1.4$	181.1 $\pm 3.0$	146.77 $\pm 0.55$	0.2002 $\pm 0.0040$	2008.133 $\pm 0.59$	223.54 $\pm 1.5$	1.6105 $\pm 0.011$	1.119 $\pm 0.015$	-1.11820	-0.04061	-0.02753	0.93569
9626 Ba,Bb	176.20 $\pm 0.49$	338.71 $\pm 0.34$	134.23 $\pm 0.25$	0.5788 $\pm 0.0023$	1864.252 $\pm 0.083$	256.53 $\pm 2.1$	1.4034 $\pm 0.012$	1.450 $\pm 0.015$	-1.37241	-0.27689	-0.46286	0.97523
12880	95.1 $\pm 8.2$	129.1 $\pm 13.3$	146.9 $\pm 4.3$	0.514 $\pm 0.11$	1884.330 $\pm 5.1$	900.5 $\pm 301$	0.3998 $\pm 0.13$	3.372 $\pm 0.047$	2.37253	-1.92335	-1.54185	-2.76484
14412	177.3 $\pm 1.7$	276.2 $\pm 1.3$	130.6 $\pm 1.5$	0.591 $\pm 0.011$	1976.039 $\pm 0.06$	56.87 $\pm 0.15$	6.3302 $\pm 0.017$	0.169 $\pm 0.022$	-0.02338	-0.10836	-0.16727	0.01978

**Table 11.** New ephemerides of ADS 8739, 9182 Aa,Ab, 9626 Ba,Bb, 12880 and 14412.

Epoch	ADS 8739		ADS 9182 Aa,Ab		ADS 9626 Ba,Bb		ADS 12880		ADS 14412	
	$\rho$ ( $''$ )	$\theta$ ( $^{\circ}$ )	$\rho$ ( $''$ )	$\theta$ ( $^{\circ}$ )	$\rho$ ( $''$ )	$\theta$ ( $^{\circ}$ )	$\rho$ ( $''$ )	$\theta$ ( $^{\circ}$ )	$\rho$ ( $''$ )	$\theta$ ( $^{\circ}$ )
2013.0	0.996	108.8	0.891	172.0	2.223	4.5	2.707	218.0	0.181	52.7
2014.0	0.948	112.0	0.890	169.9	2.220	4.1	2.715	217.6	0.181	49.8
2015.0	0.897	115.5	0.888	167.8	2.218	3.8	2.724	217.2	0.181	46.9
2016.0	0.843	119.5	0.887	165.7	2.215	3.4	2.732	216.7	0.180	44.0
2017.0	0.787	124.1	0.885	163.6	2.212	3.1	2.740	216.3	0.179	41.0
2018.0	0.730	129.4	0.883	161.5	2.208	2.8	2.748	215.9	0.178	38.0
2019.0	0.674	135.5	0.881	159.4	2.204	2.4	2.757	215.4	0.176	35.0
2020.0	0.619	142.7	0.879	157.2	2.200	2.1	2.765	215.0	0.173	31.9
2021.0	0.569	151.3	0.877	155.1	2.196	1.7	2.773	214.6	0.170	28.7
2022.0	0.527	161.4	0.875	153.0	2.191	1.4	2.781	214.1	0.167	25.3

**Table 12.** Physical parameters ( $\pi_{\text{dyn}}$ ,  $a$  and  $\mathfrak{M}_{\text{total}}$ ) derived from the new orbital elements.

Name	HIP	$m_V$	$\Delta m_V$	Spectral type	$\pi_{\text{dyn}}$ (mas)	$\pi_{\text{HIP}}$ (mas)	$a$ ( $''$ )	$a$ (AU)	$\mathfrak{M}_{\text{total}}$ ( $M_{\odot}$ )	Source of $\pi_{\text{HIP}}$
ADS 8739	63503	5.02	2.86	F2V	41.4	40.06	1.22	30.45	2.56	ESA (1997)
"	"	"	"	"	"	$\pm 0.60$	$\pm 0.04$	$\pm 1.14$	$\pm 0.29$	van Leeuwen (2007)
"	"	"	"	"	"	39.30	"	31.04	2.71	van Leeuwen (2007)
"	"	"	"	"	"	$\pm 0.38$	"	$\pm 1.11$	$\pm 0.29$	van Leeuwen (2007)
ADS 9182 Aa,Ab	69653	7.73	0.19	G0V	23.8	23.46	1.119	47.70	2.17	ESA (1997)
"	"	"	"	"	"	$\pm 1.93$	$\pm 0.015$	$\pm 3.97$	$\pm 0.54$	van Leeuwen (2007)
"	"	"	"	"	"	24.65	"	45.40	1.87	van Leeuwen (2007)
"	"	"	"	"	"	$\pm 1.34$	"	$\pm 2.54$	$\pm 0.32$	van Leeuwen (2007)
ADS 9626 Ba,Bb	75415	7.09	0.54	G0V	27.8	26.82	1.450	54.06	2.40	ESA (1997)
"	"	"	"	"	"	$\pm 0.89$	$\pm 0.015$	$\pm 1.88$	$\pm 0.25$	van Leeuwen (2007)
"	"	"	"	"	"	27.73	"	52.29	2.17	van Leeuwen (2007)
"	"	"	"	"	"	$\pm 0.65$	"	$\pm 1.34$	$\pm 0.17$	van Leeuwen (2007)
ADS 12880	97165	2.89	3.38	B9.5IV	22.0	19.07	3.372	176.8	6.8	ESA (1997)
"	"	"	"	"	"	$\pm 0.45$	$\pm 0.047$	$\pm 4.9$	$\pm 4.6$	van Leeuwen (2007)
"	"	"	"	"	"	19.77	"	170.6	6.1	van Leeuwen (2007)
"	"	"	"	"	"	$\pm 0.48$	"	$\pm 4.8$	$\pm 4.1$	van Leeuwen (2007)
ADS 14412	103130	7.66	0.30	F1V+F3V	7.2	7.72	0.169	21.9	3.2	ESA (1997)
"	"	"	"	"	-	$\pm 0.62$	$\pm 0.022$	$\pm 3.4$	$\pm 1.5$	van Leeuwen (2007)
"	"	"	"	"	-	8.34	"	20.3	2.6	van Leeuwen (2007)
"	"	"	"	"	-	$\pm 0.52$	"	$\pm 2.9$	$\pm 1.1$	van Leeuwen (2007)



**Figure 4.** New orbits of ADS 8739 (a), ADS 9182 Aa,Ab(b), ADS 9626 Ba,Bb (c), ADS 12880 (d), and ADS 14412 (e). The observations by PISCO are plotted as filled circles which appear in red in the electronic version.

**Table 9.** ADS 12880: O-C residuals of our new orbit (after 2007). The symbol  $P$  indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) ( $''$ )	$\Delta\theta$ (O-C) ( $^\circ$ )	Observer
2007.688	$-0.017^P$	$-0.2^P$	Sca
2008.383	$-0.059$	0.6	Ant
2008.560	$-0.010$	$-0.1$	Ant
2008.660	$0.001^P$	$-0.2^P$	Pru
2008.800	0.118	0.4	StJ
2009.656	$-0.000^P$	$-0.4^P$	Sca
2010.723	0.032	0.5	Ant
2011.690	$-0.002^P$	$-0.4^P$	This paper
2012.630	$0.007^P$	$-0.2^P$	Sca
2012.687	$0.013^P$	$-0.4^P$	Sca

**Table 10.** ADS 14412: O-C residuals of our new orbit (after 1998). The symbol  $P$  indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) ( $''$ )	$\Delta\theta$ (O-C) ( $^\circ$ )	Observer
1998.665	$-0.005^P$	$1.275^P$	Pru
1999.888	$-0.008$	0.435	Hor
2000.495	$-0.023$	$-2.320$	Doc
2001.562	$-0.039$	2.666	Doc
2007.426	$-0.008$	$-0.182$	Hor
2007.602	$-0.003$	1.541	Msn
2007.825	$-0.008$	0.203	Hor
2010.482	$-0.005$	$-0.885$	Hor
2011.895	$0.014^P$	$-3.374^P$	Sca

(Burnham, 1890). In his comments he said ‘‘It is singular that so easy a pair should have been overlooked heretofore. A 6-inch aperture would probably show it’’. This object is close to the sun, at a distance of 25.4 pc. A few years after its discovery, this couple was neglected by the observers. In particular, the periastron passage of the beginning of the last century was not observed at all. This object is not easy to measure visually, because of the large magnitude difference between the two components (F2V with  $\Delta m_V = 2.86$ ). This naturally explains that the measurements are not numerous and have a large scatter.

A few orbits have been published for this object. Our previous orbit of 2005 (see Paper I) now leads to systematic residuals both for the position angle and the separation. This can be explained by the poor quality of the visual measurements and the bad coverage of the orbit by the observations used for computing the orbit in 2005 (see Paper I). In 2005, there was only one speckle measurement (made with PISCO) at that time. The situation has now improved, mainly thanks to new PISCO measurements. (see Table 6). We computed a new orbit by fitting the set of 131 observations, obtained between 1889 and 2012. Using the procedure described above, we obtained a straightforward convergence. We then discarded the bad measurements that led to very large residuals (more than  $5^\circ.8$  and  $0''.22$  for  $\theta$  and  $\rho$ , respectively). The orbital elements reported in Table 5 well fit the observations (see Fig. 4), with mean residuals of  $\Delta\rho_{O-C} = 0.10''$  and  $\Delta\theta_{O-C} = 2.4^\circ$ .

The large magnitude difference ( $\Delta m_V = 2.86$ ) suggests that the companion is a red dwarf. More precisely, the absolute magnitude of the companion ( $\pi = 0''.03930$ ,  $m_V = 7.88$ ,  $M_V = 5.85$ ) corresponds to a G9-K0V star with a theoretical mass of  $0.87 M_\odot$  (Straizys & Kurilene, 1981). The primary star has a spectral type of F2V, with a theoretical mass of  $1.35 M_\odot$ . The sum of those theoretical masses would then be  $2.22 M_\odot$ . It is slightly smaller than the value of  $2.7 M_\odot$  which is derived from our orbital parameters and the Hipparcos parallax (van Leeuwen, 2007). The corresponding uncertainty is about 11%, which is unusually small; this is due to the small parallax error value. The dynamical parallax derived from our orbit is in good agreement with the Hipparcos parallax (see Table 12).

In the next twenty years, the part of the orbit that was neglected by the observers in the beginning of the 20th century (including the periastron passage) should be covered by new observations. This should allow a final determination of this orbit.

## 4.2 New orbit of ADS 9182 Aa,Ab

### WDS 14153+0308 – STF 1819 Aa,Ab – ADS 9182 (HIP 69653):

F.G.W. Struve discovered this couple with the 25-cm refractor of Dorpat Observatory during his binary star survey made in 1825–1827. The first measurement was made in may 1828 (Struve, 1837). This object has been regularly measured by many observers, especially in the beginning of the last century, when the angular separation was maximum. The position angle measurements have a rather good quality, but the angular separation measurements have a large scatter. The reason is that most observations of this object close to the celestial equator were made from the Northern hemisphere. Its was then often measured in poor seeing conditions because its elevation above the horizon was too low.

The previous orbit of ADS 9182 Aa,Ab is that of Houser (1987) for which the most recent observations was made in 1983.82. This orbit is still rather good, but the position angle residuals begin to show systematic trend. We revised this orbit to profit from the 81 new good quality measurements obtained since 1983 and reduce the uncertainties on the orbital elements.

We revised the orbit of STF 1819 using the procedure described in the beginning of Sect. 4. Our orbit was computed with 465 observations obtained since 1828. We discarded the observations with large residuals, and set the threshold to  $0''.21$  and  $3^\circ.8$  for  $\rho$  and  $\theta$ , respectively. The orbital elements are displayed in Table 5. The final mean rms residuals were  $0''.08$  and  $1^\circ.4$  for  $\rho$  and  $\theta$ , respectively.

ADS 9182 is a binary system made of two stars of visual magnitudes of 7.73 and 7.92, with a spectral type of G0 V. The small value of  $\Delta m_V$  suggests that the two stars have a similar spectral type. The total mass of the system computed with Hipparcos parallax (van Leeuwen, 2007) is  $1.9 M_\odot$ . This value is consistent with the theoretical value of  $2 M_\odot$  which is expected for a system of two G0V stars (see Table 12).

The dynamic parallax computed by the Baize-Romani (1946)’s method is 23.8 mas which is in good agreement with Hipparcos measurements.

The periastron passage occurred a few years ago and

was monitored by PISCO (see Fig. 4) and some other speckle cameras. Those observations permitted us to greatly reduce the uncertainties on the orbital elements. A large proportion of the apparent ellipse (see Fig. 4) has been well measured now and the orbital elements should not change much in the future. This orbit is now well determined, and its degree value can be estimated at 2-3.

### 4.3 New orbit of ADS 9626 Ba,Bb

#### WDS 15245+3723 – STF 1938 Ba,Bb – ADS 9626 (HIP 75415, 51 Boo B):

This binary star was discovered by W. Herschel on July 30th 1780, as he was trying to measure stellar parallaxes. He observed this object in 1781, 1782 and 1802 and concluded that the motion was very likely orbital. The first real measures of ADS 9626 began with F.G.W. Struve in 1826. This couple was then regularly observed with numerous observations whose quality is satisfactory, especially for the position angle. Photographic measurements with long focal refractors started in 1916 and were done on a regular basis after 1949. Since its discovery, the companion has rotated of about 360 degrees around the primary star. The periastron and apoastron passages were monitored in 1864 and 1994, respectively.

Associated with the A component (51 Boo A = HR 5733) which is distant of  $109''$  (3930 A.U.), this pair forms the wide physical system STFA 28 AB (Shaya & Olling, 2011). The A component is itself a close binary (CHR 181 Aa,Ab) with an estimated orbital period of 1368 d and a systemic mass of  $3.2 M_{\odot}$  (Muterspaugh et al 2010). Therefore STF1938 Ba,Bb belongs to a wide quadruple system.

The previous orbit of this pair was computed by one of us (Scardia, 1986). Our new orbit profits from the 114 new observations that were done after 1982, which is the date of the last measurement used by Scardia (1986). For computing the new orbit, we used all the 729 observations obtained since 1782. We first rejected the measurements for which the residuals were larger than  $0''.25$  and  $5^{\circ}.26$ , for  $\rho$  and  $\theta$ , respectively. The final orbital elements are displayed in Table 5. The corresponding rms residuals are  $0''.09$  and  $1^{\circ}.5$  for  $\rho$  and  $\theta$ , respectively.

The spectral type of the primary is G0V. Likewise, the rather small magnitude difference (0.5 mag) suggests that the companion is also a dwarf G star. The sum of the masses ( $2.2 M_{\odot}$ ) is in good agreement with the expected theoretical value. Likewise, the dynamical parallax is in excellent agreement with Hipparcos parallax computed by van Leeuwen (2007) (see Table 12).

The uncertainties of the new orbital elements are much smaller than the previous published values (Scardia, 1986). They have been reduced by about 50%, thanks to the introduction of 114 new observations made since 1982. Moreover, the uncertainty on the sum of the masses is about ten times smaller than the values published in 1986. This is also due to the more accurate parallaxes obtained by Hipparcos.

### 4.4 New orbit of ADS 12880

#### WDS 19450+4508 – STF 2579 – ADS 12880 (HIP 97165, $\delta$ Cyg):

This couple is sometimes known as H 1 94 since it was first discovered by W. Herschel on Sept. 20th 1783 with his 12-inch telescope. F.G.W. Struve re-discovered this couple in 1826 with the 25-cm refractor of Dorpat Observatory and reported it as the 2579th binary in his catalogue. A detailed story of the old observations of this object can be found in Baize (1930).

The primary star ( $\delta$  Cyg) is very bright ( $m_V = 2.89$ ) whereas its companion is very faint and likely to be variable ( $m_V > 6.27$ , Baize & Petit, 1989). The first published orbits had a large uncertainty, and the observations made before 1930 were similarly explained by short (300 yr) or long (1000 yr) orbital periods (Burnham, 1897, and Baize, 1930). The subsequent observations of the last 80 years favoured long period values, in the range 700–1100 yr.

Although the large magnitude difference hindered visual measurements, the observations are superabundant. The position angle was generally rather well measured but the reported angular separation values have large uncertainties. We have been regularly observing ADS 12880 with PISCO since 2004. Our measurements are the only speckle values obtained after 1997.

Our previous orbit (Scardia, 1983) is still good, but we wanted to improve it thanks to the 72 good-quality measurements obtained in the last 30 years. For revising this orbit, we used the 435 observations obtained since 1783. We first rejected the bad measurements with residuals larger than  $0''.34$  and  $5^{\circ}.3$  for  $\rho$  and  $\theta$ , respectively. The new orbital elements reported in Table 5. lead to mean rms residuals of  $0''.15$  and  $1^{\circ}.9$  for  $\rho$  and  $\theta$ , respectively.

The two components of ADS 12880 have a large magnitude difference ( $\Delta m_V = 3.38$ ). Using Pogson's formula, the companion would have an absolute visual magnitude of 2.75 mag ( $\pi = 19.77$  mas,  $m_V = 6.27$ ) which corresponds to a spectral type A9-F0V, whose theoretical mass is  $1.45 M_{\odot}$  (Straizys & Kuriliene, 1981). The expected mass of the primary star (B9.5IV) is  $2.63 M_{\odot}$ . The total theoretical mass of ADS 12880 is therefore  $4.11 M_{\odot}$ . When taking into account the (large) estimated errors this is compatible with the total mass derived from our orbit and Hipparcos parallax ( $6.1 \pm 4.1 M_{\odot}$ ).

Since the primary star is a sub-giant B9.5 IV, we computed the dynamical parallax with our revised version of the Baize-Romani's method for luminosity-class IV (Scardia et al., 2008b). The value we obtained is in good agreement with Hipparcos measurement (see Table 12).

The estimated errors on the orbital elements are rather large. In particular the orbital period has an uncertainty of about 30%. An arc of orbit of about  $210^{\circ}$  has already been monitored, but it is located on either side of the periastron and the measurements have a large scatter, which impedes an accurate determination of the orbit. This long period orbit ( $P \approx 900$  yr) is still uncertain (degree 4).

### 4.5 New orbit of ADS 14412

#### WDS 20537+5918 – A 751 – ADS 14412 (HIP 103130):

This couple was discovered by R.G Aitken with the 91-cm refractor of Lick Observatory on June 26th 1904 (Aitken, 1904). It is difficult to observe, even with big refractors. Since 1976, most observations have been done with speckle

interferometry. Two orbital revolutions have been monitored since its discovery, including one periastron passage for which a separation close to  $0''.05$  was observed.

Seven orbits of A 751 have been computed until now. The last orbits of Heintz (1986) and Hartkopf et al. (1989) lead to systematic residuals for the position angle. We propose a new orbit that takes profit of the observations made in the last twenty years, mainly in speckle interferometry. We used a total of 74 observations obtained since 1904. The orbital elements presented in Table 5 lead to mean rms residuals of  $0''.022$  and  $3''.6$  for  $\rho$  and  $\theta$ , respectively.

The computed sum of the masses with Hipparcos parallax (van Leeuwen, 2007) is  $2.6 \pm 1.1 M_{\odot}$ , which is consistent with the theoretical mass of two F1V and F3V stars (Straizys and Kuriliene, 1981). The dynamical parallax computed with Baize-Romani (1946)'s method is 7.2 mas, is in fair agreement with the measured parallax.

The orbital elements are now well defined and should not change much in the future. This orbit can be considered as grade 2.

## 5 CONCLUSION

In 2011, we obtained new measurements of 469 visual binaries with PISCO in Merate, with an average accuracy of  $0''.02$  for the angular separation and  $0''.7$  for the position angles. The total number of measurements made in Merate since 2004 now exceeds 2800. Our group has thus provided a good contribution to the continuing monitoring of long period visual binary systems, which is important for refining systemic stellar masses.

In 2011, we added a 32 mm eyepiece in the magnification wheel of PISCO. This new low magnification option allowed us to observe fainter stars than previously. The limiting magnitude of our instrumentation on the Zeiss telescope is now close to  $m_V = 10 - 12$ . Some red dwarf stars are thus present in the HR diagram. We have made a new calibration both of the scale and orientation of PISCO. The new values are very close to our previous calibration made in 2004.

We finally presented new orbital elements computed for ADS 8739, 9182 Aa,Ab, 9626 Ba,Bb, 12880 and 14412. Those orbits were partly derived from our observations. The total mass values we have obtained are compatible with the expected theoretical values.

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by the *Centre de Données Astronomiques de Strasbourg* (France).

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