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Speckle observations with PISCO in Merate. VI. Astrometric measurements of visual binaries in 2006

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We present relative astrometric measurements of visual binaries made during the second semester of 2006, with the speckle camera PISCO at the 102 cm Zeiss telescope of Brera Astronomical Observatory, in Merate. Our sample contains orbital couples as well as binaries whose motion is still uncertain. We obtained 175 new measurements of 169 objects, with angular separations in the range $0''.1$ — $4''.2$, and an average accuracy of $0''.01$. The mean error on the position angles is $0^\circ.6$. Most of the position angles could be determined without the usual 180° ambiguity with the application of triple-correlation techniques and/or by inspection of the long integration files.

We also present the new orbits we have computed for ADS 11479, 11584 and 16538, for which our measurements lead to large residuals and/or for which the revision was justified by the significant number of observations made since the last orbit computation.

1 Introduction

This paper is the sixth of a series (Scardia et al. 2005, 2006, 2007, 2008a, Prieur et al. 2008, herein: Papers I to V), whose purpose is to contribute to the determination of binary orbits, using speckle observations made in Merate (Italy) 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). PISCO was developed at *Observatoire Midi-Pyrénées* and first used at *Pic du Midi* from 1993 to 1998. It was moved to Merate in 2004 and used there since. More information about the context and the purpose of this program can be found in Paper I.

This paper deals with the results of the observations performed during the second semester of 2006. In Sect. 2, we briefly describe our sample, the instrumental setup and the reduction procedure. The astrometric measurements are presented and discussed in Sect. 3. In Sect. 4 we propose new revised orbits for ADS 11479, 11584 and 16538, partly derived from those observations and derive estimates of the component masses.

2 Observations and data reduction

The purpose of our long term program is to monitor the relative motion of all visual binaries accessible with PISCO on the Zeiss telescope in Merate, for which new measurements are needed to improve their orbits. Our sample consists of visual binaries with the following characteristics, that are linked to instrumental or atmospheric limitations:

- declination north of -5°,
- brighter than 10th magnitude in V,
- magnitude difference less than 4,
- angular separation smaller than $\approx 5''$.

The last limitation was chosen so that the binary systems fit inside the isoplanatic patch of the atmosphere, which is a theoretical necessary condition for speckle measurements. The distribution of the angular separations measured in this paper is displayed in Fig. 1 and shows a maximum for $\rho \approx 0''.7$. The closest separation that can be measured with PISCO in Merate is of the order of the diffraction limit, which is $\lambda/D \approx 0''.13$ with the R filter (i.e. $\lambda = 650$ nm) and the Zeiss telescope whose diameter is $D = 1.02$ m.

The observations were carried out with the PISCO speckle camera with the ICCD detector (CCD intensified with a micro-channel plate) belonging to Nice University (France). Details about the telescope and the instrumentation can be found in Paper I and in Prieur et al. (1998). For each observation, a series of about 10 000 short-exposure frames were digitized and processed in real-time with a Pentium III PC, to compute the mean auto-correlation with Worden's (1977)

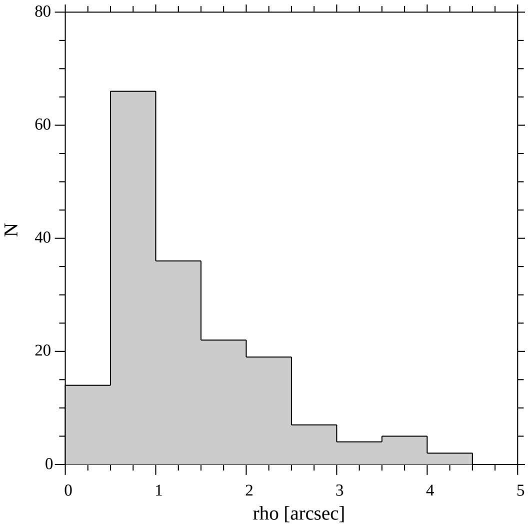

Fig. 1 Histogram of the angular separations of the 175 measurements reported in this paper.

method (which subtracts most of the continuum), the mean power spectrum and the integration of the individual frames. Those frames were also recorded on a SVHS video tape for archiving and further processing such as the quadrant determination.

As the auto-correlation function is symmetric relative to the origin, it does not contain information about the location of the faintest companion. This is the origin of the well-known 180° ambiguity of binary speckle measurements. This ambiguity can be resolved by using the mean triple-correlation function of the elementary frames (Weigelt, 1977) or a restricted version of this function as proposed by Aristidi et al. (1997), which is the method we use (see Paper III).

The positions of the secondary peaks of the mean auto-correlations were carefully measured with an interactive program that fitted and subtracted the residual background. The details of this procedure with an evaluation of the reliability of the determination of the errors can be found in Paper III. For the binaries with the smallest separations (i.e. $\rho \lesssim 0''.3$) we also subtracted a model of the central background pattern to the auto-correlation images, as described in Paper IV.

3 Astrometric measurements

The astrometric measurements of the observations made during the second semester of 2006 are displayed in Table 1. The designation of the binary is reported in the first three columns: the WDS name (Washington Double Star Catalogue, Mason et al. 2007) in Col. 1, the official double star designation in Col. 2 (sequence is "discoverer-number"), and the ADS number in Col. 3 (Aitken, 1932). 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 ρ (Col. 7) with its error (Col. 8) in arcseconds, and the position angle θ (Col. 9) with its error (Col. 10) in degrees.

The characteristics of the PISCO R and V filters were given in Table 1 of Paper III. Some objects, like ADS 9426 and 10949, were observed without any filter because they were too faint. This is indicated with W (for "white" light) in the filter column (Col. 5). The corresponding bandpass is that of the ICCD detector, with a central wavelength of about 650 nm, close to that of the R filter.

The errors reported in Cols. 8 and 10 were computed by adding quadratically the calibration errors to the standard deviations of series of measurements obtained with the same data sets (see Paper III). As for the previous papers of this series, the minimum (one-sigma) errors for the angular separation (Col. 8) were set to $0''.003$ for close pairs and to 0.05% of ρ for wide pairs, on the basis of the uncertainties coming from the determination of the centres of the auto-correlation peaks (estimated at 0.1 pixel in the elementary frames) and those affecting the scale calibration (i.e., 0.05%), respectively. Similarly, the minimum (one-sigma) errors for the position angle (Col. 10) were estimated at $0^\circ.3$. The average values of the errors of the 175 measurements reported in this table are $0''.012 \pm 0''.005$ and $0^\circ.56 \pm 0^\circ.34$ for ρ and θ, respectively. The validity of our error determination was studied in detail in Paper III.

The position angles presented in Col. 9 follow the standard convention with the North corresponding to $\theta = 0^\circ$ and the East to $\theta = 90^\circ$. When the triple correlation files allowed us to resolve the 180° ambiguity (see Sect. 2 and 3.1), an asterisk was added in Col. 9 to indicate that our determination is absolute. Otherwise, our angular measurements were reduced to the quadrant reported in the "Fourth Catalogue of Interferometric Measurements of Binary Stars" (Hartkopf et al. 2008, hereafter IC4).

In Col. 11, a flag is set to one for all the systems for which an orbit was found in the literature, e.g., mainly from the "Sixth Catalogue of Orbits of Visual Binary Stars" (Hartkopf & Mason, 2008), hereafter OC6. The residuals derived from the corresponding ephemerides will be discussed in Sect. 3.2.

In the note column (Col. 12), we give some comments about the secondary peaks of the auto-correlation files that have been measured (e.g., elongated, diffuse, faint, etc). An elongation of those peaks is generally a sign of an insufficient correction of the atmospheric dispersion by the Risley prisms (see Prieur et al., 1998). The auto-correlation files of ADS 13447 exhibited some spurious multiple peaks whose origin is unknown.

Table 1 Measurements of visual binaries between July and December 2006 (begin.).

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	ρ (arcsec)	σ_ρ (arcsec)	θ (deg.)	σ_θ (deg.)	Orb.	Notes
01283+4247	AC 14	1161	2006.954	R	20	0.768	0.019	92.1*	0.5	0	
14536−0028	BU 942	9426	2006.499	W	20	1.388	0.028	185.7	1.3	0	
15361+5531	A 1124	9720	2006.499	R	20	1.399	0.027	141.0*	1.1	0	
16413+3136	STF 2084	10157	2006.642	R	10	1.019	0.005	208.7*	0.5	1	
16442+2331	STF 2094AB	10184	2006.655	R	20	1.185	0.008	72.7*	0.6	0	
16518+2840	STF 2107AB	10235	2006.680	R	20	1.452	0.008	99.6*	0.3	1	
16541+0826	HEI 857	–	2006.680	R	20	0.563	0.008	142.2*	0.5	0	
16564+6502	STF 2118AB	10279	2006.639	R	20	1.067	0.008	66.2*	0.3	1	
17020+0827	STF 2114	10312	2006.674	R	20	1.343	0.008	193.8*	0.3	0	
17053+5428	STF 2130AB	10345	2006.639	R	20	2.360	0.012	11.8*	0.3	1	
17096+0356	HEI 894	–	2006.696	R	20	0.553	0.009	21.8*	0.8	0	
17195+5832	KR 46	10487	2006.642	R	20	1.695	0.010	63.3*	0.6	0	
17239+3627	STF 2162	10527	2006.674	R	20	1.355	0.010	282.2	0.7	0	
17240+3835	HU 1179	10531	2006.675	R	10	0.247	0.006	274.4	0.3	1	
17304−0104	STF 2173	10598	2006.680	R	10	0.451	0.003	166.2*	0.3	1	Elongated
17358+0100	STF 2186	10650	2006.639	R	20	3.022	0.015	78.2*	0.3	0	
17386+5546	STF 2199	10699	2006.694	R	20	2.007	0.010	56.5*	0.3	1	
17397+7256	H 1 41	10734	2006.639	R	20	1.036	0.008	336.0*	0.4	0	
17399+0748	HDS2499	–	2006.639	R	20	0.680	0.008	239.3*	0.9	0	
17436+2237	HU 1285	10743	2006.677	R	20	0.546	0.008	215.0*	0.4	1	
17439+0551	STF 2200AB	10741	2006.677	R	20	1.594	0.008	162.8*	0.3	0	
17457+1743	STF 2205	10769	2006.696	R	20	1.076	0.008	358.3*	0.3	1	
17471+1742	STF 2215	10795	2006.677	R	10	0.505	0.003	254.8*	0.3	1	
17533+3605	STF 2243	10874	2006.642	R	20	1.141	0.014	39.8	0.6	0	
17571+0004	STF 2244	10912	2006.680	R	10	0.611	0.003	97.8*	0.4	1	
17571+4551	HU 235	10934	2006.680	R	20	1.608	0.008	282.9*	0.3	0	
17590+0202	STF 2252AB	10945	2006.696	R	20	3.958	0.020	23.5	0.3	0	
17590+1226	STF 2254AB	10949	2006.675	W	20	3.502	0.018	265.6*	0.3	0	Diffuse
18003+5251	STF 2271AB	10988	2006.677	R	20	3.395	0.017	267.1*	0.3	0	
18017+4011	STF 2267	11001	2006.642	R	20	0.567	0.008	269.9	0.5	0	
18025+4414	BU 1127Aa-B	11010	2006.639	R	20	0.775	0.008	55.2*	0.7	1	
18065+4022	STF 2282	11074	2006.639	R	20	2.657	0.013	81.8*	0.4	0	
18096+0400	STF 2281AB	11111	2006.718	W	10	0.602	0.010	291.0*	0.7	1	
”	”	”	2006.721	R	20	0.588	0.008	290.8*	1.0	1	
18097+5024	HU 674	11128	2006.677	R	20	0.753	0.008	216.1*	0.7	1	
18101+1629	STF 2289	11123	2006.694	R	20	1.231	0.008	219.2*	0.3	1	
18146+0011	STF 2294	11186	2006.696	R	20	1.295	0.014	92.6	0.6	1	
18208+7120	STT 353AB	11311	2006.699	R	10	0.480	0.004	267.6*	0.3	1	
18238+5139	ES 187AB	11328	2006.642	R	20	2.561	0.014	206.0	0.3	0	
18250−0135	AC 11	11324	2006.696	R	20	0.873	0.008	354.7*	0.3	1	
18250+2724	STF 2315AB	11334	2006.696	R	10	0.642	0.003	121.2	0.3	1	
18261+0047	BU 1203	11339	2006.726	R	20	0.459	0.009	153.9*	0.5	1	
18272+0012	STF 2316Aa-B	11353	2006.726	R	20	3.681	0.018	319.8*	0.3	0	
18320+0647	STT 354	11432	2006.699	R	20	0.610	0.008	210.8	1.3	0	
18338+1744	STF 2339AB-D	11454	2006.699	R	20	2.081	0.010	273.5*	0.4	0	(outer autoc. peaks)
”	”	”	2006.716	R	20	2.058	0.013	273.7*	0.4	0	
18338+1744	STF 2339AB-C	11454	2006.699	R	20	1.632	0.014	276.4*	0.4	0	(inner autoc. peaks)
”	”	”	2006.715	W	20	1.640	0.008	275.3*	0.5	0	
”	”	”	2006.716	R	20	1.627	0.008	275.8*	0.4	0	
”	”	”	2006.715	W	10	–	–	–	–	0	Too diffuse
18338+1744	WAK 21CD	11454	2006.699	R	20	0.441	0.018	265.5*	0.5	0	
18339+5221	A 1377AB	11468	2006.677	R	10	0.251	0.005	120.7*	0.6	1	Elongated
18355+2336	STT 359	11479	2006.639	R	10	0.729	0.004	5.6	0.3	1	
18359+1659	STT 358AB	11483	2006.675	R	20	1.655	0.008	151.8*	0.3	1	
18374+7741	STT 363	11584	2006.727	R	20	0.431	0.013	336.9	0.7	1	
18384+2842	STF 2356	11529	2006.642	R	20	1.125	0.010	62.8	0.5	0	

Table 1 Measurements of visual binaries between July and December 2006 (cont.).

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	ρ (arcsec)	σ_ρ (arcsec)	θ (deg.)	σ_θ (deg.)	Orb.	Notes
18387+0451	STT 360	11526	2006.743	R	20	1.672	0.008	281.4*	0.3	0	
18393+2056	STF 2360	11546	2006.677	R	20	2.432	0.012	358.3*	0.3	0	
18413+3018	STF 2367AB	11579	2006.743	R	10	0.378	0.003	75.4	0.5	1	
18443+3940	STF 2382AB	11635	2006.675	R	20	2.380	0.012	348.8*	0.3	1	
18443+3940	STF 2383Cc-D	11635	2006.675	R	20	2.381	0.012	79.5*	0.3	1	
18443+6103	STF 2403	11661	2006.680	R	20	1.091	0.008	277.2*	0.3	0	
18477+4904	HEI 72	–	2006.724	R	20	0.618	0.008	231.4*	0.6	0	
18490+2110	STF 2401AB	11715	2006.724	W	20	4.248	0.021	37.7*	0.3	0	
18497+1041	STF 2402	11722	2006.784	R	20	1.455	0.008	208.8*	0.6	0	
18502+1131	BU 265	11735	2006.784	R	20	1.390	0.013	228.4*	0.3	0	
18508+1059	STF 2404	11750	2006.694	R	20	3.534	0.018	181.2*	0.3	0	
18520+1047	STF 2408	11766	2006.784	W	20	2.286	0.011	90.7*	0.3	0	Elongated
18521+1148	HU 199	11769	2006.789	R	20	0.884	0.011	345.6*	1.0	0	
18526+1400	STF 2412	11778	2006.694	R	20	1.449	0.008	55.9	0.3	0	
18555+2914	STF 2419	11847	2006.789	R	20	3.363	0.017	176.9*	0.3	0	
18570+3254	BU 648AB	11871	2006.721	R	20	0.898	0.008	268.8*	0.3	1	
18575+5814	STF 2438	11897	2006.716	R	10	0.867	0.008	359.6*	0.3	1	
19019+1910	STF 2437	11956	2006.743	R	20	0.580	0.016	11.1	0.3	1	
19024+6927	STF 2478	12015	2006.680	W	20	0.953	0.008	313.6*	0.5	0	
19030+5135	STF 2451	11997	2006.677	W	20	1.984	0.010	81.9*	0.4	0	
19052+1050	BU 466	12021	2006.669	W	20	1.916	0.010	163.8*	0.3	0	
19062+3026	STF 2454AB	12040	2006.822	W	20	1.326	0.019	288.6*	0.5	1	
19070+1104	HEI 568	–	2006.724	R	10	0.304	0.004	274.9*	0.4	0	
19071+7204	STT 369	12113	2006.721	R	20	0.695	0.011	11.3*	0.5	0	
19083+5520	D 19AB	12104	2006.727	R	20	0.511	0.016	348.6*	1.1	0	
19114+2116	A 151	12140	2006.819	R	20	0.574	0.011	156.2	0.7	0	
19143+1904	STF 2484	12201	2006.694	R	20	2.163	0.011	238.9*	0.3	1	
19148+4756	A 706	12229	2006.789	R	20	1.600	0.014	73.4	0.5	0	
19220+2230	BU 141AB	12355	2006.694	R	20	0.895	0.008	82.1	0.9	0	
19251+1839	HU 339	12416	2006.792	W	20	0.834	0.008	243.5	0.7	0	Diffuse & elongated
19261+3849	HO 450AB	12446	2006.697	R	20	1.000	0.013	264.1	0.8	0	
19266+2719	STF 2525	12447	2006.677	R	20	2.130	0.016	289.7*	0.3	1	
19270+7322	STF 2550AB	12524	2006.680	R	20	1.942	0.010	250.8	0.3	0	
19299+4931	BU 143	12535	2006.697	W	20	2.188	0.017	192.3*	0.3	0	
19307+2758	MCA 55Aac	12540	2006.721	R	10	0.359	0.012	105.5*	1.3	1	
19311+0824	A 1184	12537	2006.743	W	20	0.901	0.024	108.4*	0.4	0	Elongated
19346+1808	STT 375	12623	2006.721	R	20	0.601	0.015	182.5*	1.2	0	
19350+2947	A 368	12633	2006.699	R	20	0.507	0.011	153.2*	0.8	0	
19357+7308	A 864	12729	2006.727	W	20	0.742	0.008	14.5*	1.3	0	
19363+3540	STT 377AB	12667	2006.819	R	20	0.985	0.035	36.1	1.7	0	
19365+4101	STT 378AB	12687	2006.699	R	20	1.406	0.008	285.5*	0.3	0	
19384+0021	BU 249AB	12708	2006.852	R	20	0.831	0.017	109.9*	1.0	0	
19402+2331	A 166	12770	2006.830	R	20	0.821	0.015	241.2	1.2	0	
”	”	”	2006.830	W	20	0.805	0.017	62.4*	0.7	0	
19413+3043	BU 145AB	12786	2006.852	R	20	0.825	0.011	269.5*	0.8	0	
19448+1649	STF 2569	12861	2006.830	R	20	2.119	0.015	357.0*	0.3	0	
19450+4508	STF 2579AB	12880	2006.721	R	20	2.666	0.013	220.4*	0.3	1	
”	”	”	2006.762	R	20	2.647	0.013	220.5*	0.3	1	
19453+3048	AG 237	12881	2006.762	W	20	2.375	0.018	140.2*	0.5	0	
19456+3337	STF 2576AB	12889	2006.699	R	20	2.832	0.014	160.4	0.3	1	
19483+3710	STT 386	12965	2006.669	R	20	0.933	0.011	69.8	0.9	0	
19487+3519	STT 387	12972	2006.724	R	20	0.571	0.018	129.6*	0.8	1	
19575+2018	BU 425AB	13165	2006.852	W	20	1.342	0.026	240.0	0.6	0	Elongated
20011+4816	STF 2619AB	13269	2006.784	R	20	4.166	0.021	239.3*	0.3	0	
20014+1045	STF 2613	13256	2006.727	R	20	3.637	0.018	354.2*	0.3	1	

Table 1 Measurements of visual binaries between July and December 2006 (cont.).

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	ρ (arcsec)	σ_ρ (arcsec)	θ (deg.)	σ_θ (deg.)	Orb.	Notes
20042+1148	STF 2620AB	13320	2006.830	R	20	1.849	0.009	286.1*	0.5	0	
20067+1256	BU 428	13384	2006.727	R	20	0.788	0.008	353.6	0.7	0	
20095+5140	STF 2645	13447	2006.789	R	20	1.594	0.010	138.5	0.8	0	Multiple peaks
20102+4357	STT 400	13461	2006.699	R	20	0.593	0.008	337.4	0.7	1	
20187+3315	STT 405AB	13682	2006.819	R	20	0.799	0.017	150.6	0.7	0	
20200+3616	BU 431	13719	2006.820	R	20	0.530	0.008	29.8*	1.8	0	
20229+4259	HO 128AB	13786	2006.820	R	20	1.361	0.021	358.8*	0.6	0	
20244+2923	HO 457AB	13818	2006.830	W	20	2.021	0.010	60.4*	0.3	0	Elongated
20248+3545	BU 432	13830	2006.831	R	20	1.433	0.019	196.5*	0.5	0	
20337+3835	A 1431	14007	2006.789	R	20	0.867	0.011	30.6	0.6	0	
20370+1203	STF 2701	14063	2006.697	R	20	2.057	0.020	221.1*	0.5	0	
20375+1436	BU 151AB	14073	2006.790	R	10	0.532	0.003	5.5*	0.3	1	
20445+2356	STF 2724	14227	2006.784	R	20	2.466	0.017	149.0	0.3	0	
20471+2525	BU 364	14286	2006.784	R	20	0.792	0.014	68.4	0.6	0	
20474+3629	STT 413Aa-B	14296	2006.784	R	20	0.876	0.008	5.7*	0.5	1	
20531+2909	STT 417AB	14397	2006.790	R	20	0.880	0.015	28.2	0.7	0	
20553+4231	STT 423	14432	2006.918	R	20	2.766	0.014	76.1*	0.3	0	
20557+0432	STF 2735	14430	2006.820	R	20	2.032	0.017	281.5*	0.3	0	
20577+5849	A 756AB	14493	2006.918	R	20	0.565	0.018	209.3	2.1	0	
20591+0418	STF 2737AB	14499	2006.869	R	10	0.632	0.004	284.5	0.3	1	
20595+5013	BU 68	14520	2006.918	R	20	1.941	0.025	148.7*	0.3	0	
20598+6152	BU 472	14540	2006.831	R	20	0.743	0.011	13.9*	0.4	0	
21015+6643	HU 959	14578	2006.831	R	20	1.296	0.012	160.6*	0.3	0	
21137+6424	H 1 48	14783	2006.727	R	10	0.229	0.004	235.7	1.6	1	
21186+1134	BU 163AB	14839	2006.727	R	20	0.757	0.008	257.8	0.8	1	
21237+5518	A 1892	14945	2006.727	R	20	0.747	0.009	348.7	0.7	0	
21289+1105	STF 2799AB	15007	2006.727	R	20	1.854	0.009	261.9	0.6	1	
21308+4752	A 769	15053	2006.943	R	20	0.704	0.014	292.9	1.0	0	Diffuse
21355+2427	HU 371	15115	2006.953	R	10	0.255	0.003	314.6	0.7	1	
21441+2845	STF 2822AB	15270	2006.784	R	20	1.781	0.009	311.3*	0.3	1	
21454+4356	HO 168AB	15295	2006.831	R	20	0.855	0.017	223.4	0.6	0	
21480+6920	STF 2835	15350	2006.918	W	20	1.904	0.012	270.1*	0.6	0	
21555+1053	BU 75AB	15447	2006.784	R	20	0.906	0.008	19.9	1.0	1	
21557+0715	STT 452	15452	2006.915	R	20	0.744	0.014	178.2	0.4	0	
21565+0715	STT 453AB	15464	2006.915	R	20	0.717	0.012	268.1	0.5	0	
21581−0329	STF 2847	15494	2006.953	R	20	0.731	0.017	125.8	0.9	0	
22009+6250	HU 976	15558	2006.820	W	20	1.609	0.008	54.9	0.3	0	
22070+3605	STT 462AB	15645	2006.831	R	20	1.079	0.014	316.8*	0.5	0	
22086+5917	STF 2872BC	15670	2006.790	R	20	0.829	0.022	298.4	0.3	1	
22094+2233	STF 2868	15673	2006.954	R	20	1.077	0.014	352.3*	0.4	0	
22100+2308	COU 136	–	2006.954	R	20	0.485	0.012	27.7*	0.6	1	
22122+6344	STF 2884	15742	2006.918	W	20	2.118	0.015	142.6*	0.3	0	
22272+1509	STF 2905	15950	2006.915	W	20	3.326	0.017	104.5*	0.4	0	Diffuse
22312+5052	STF 2918	16020	2006.915	R	20	1.643	0.015	236.8*	0.5	0	Diffuse
22323+5512	AG 283	16032	2006.831	W	20	2.640	0.013	332.1*	0.3	0	
22328+2625	HO 475AB	16037	2006.951	W	20	1.085	0.008	126.0*	0.8	0	
22419+2126	STF 2934	16185	2006.951	W	20	1.337	0.008	57.9*	0.4	1	
22426+4401	A 414AB	16204	2006.951	W	20	1.723	0.009	14.1	0.3	0	Diffuse
22485+5409	AG 424	16280	2006.973	R	20	2.266	0.013	135.5*	0.4	0	
22509+5303	BU 1332AB	16310	2006.918	W	20	1.509	0.013	128.3*	0.4	0	
22514+6142	STF 2950AB	16317	2006.784	R	20	1.293	0.008	278.9*	0.3	0	
22537+4445	BU 382AB	16345	2006.869	R	20	0.823	0.008	230.7*	0.3	1	
22557+1547	HU 987	16373	2006.790	W	20	1.110	0.008	78.9*	0.3	1	
22597+4149	HLD 56	16435	2006.790	W	20	1.158	0.008	93.1*	0.6	0	
23072+6050	BU 180AB	16518	2006.869	R	20	0.548	0.013	136.1*	0.6	0	

Table 1 Measurements of visual binaries between July and December 2006 (end).

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	ρ (arcsec)	σ_ρ (arcsec)	θ (deg.)	σ_θ (deg.)	Orb.	Notes
23078+6338	HU 994	16530	2006.869	R	10	0.200	0.004	314.9	1.3	1	
23079+7523	STT 489AB	16538	2006.869	R	20	1.094	0.019	350.8^*	0.8	1	
23102+5727	STT 490AB	16560	2006.869	W	20	1.200	0.008	296.5^*	0.3	0	
23147+4116	A 200	16621	2006.954	R	20	0.652	0.014	74.7	2.2	0	Faint & diffuse
23292+4042	A 1487	16785	2006.954	R	20	1.063	0.015	158.8	0.5	0	
23340+3120	BU 720	16836	2006.975	R	10	0.554	0.005	97.7^*	0.4	1	
23375+4426	STT 500AB	16877	2006.975	R	10	0.463	0.003	8.4^*	0.5	1	
23413+3234	BU 858AB	16928	2006.975	R	20	0.830	0.012	224.0^*	0.8	0	
23431+1150	A 1242	16951	2006.976	W	20	0.940	0.015	333.6	1.2	1	
23516+4205	STT 510AB	17050	2006.954	R	20	0.590	0.008	120.0^*	1.1	0	
23590+5315	HLD 59AB	17141	2006.954	R	20	1.155	0.013	12.5	0.7	0	

Note: In column 9, the exponent * indicates that the position angle θ could be determined without the 180° ambiguity.

Note that the case of ADS 11454 is noteworthy: it is a quadruple system that we detected as triple only because the two components A and B are presently too close ($\rho < 0''.1$) to be resolved with the 102 cm Zeiss telescope (see discussion in the next section). In order to provide the maximum accuracy, our measures of STF 2339 refer to the position of the components C and D relative to that of the unresolved couple AB. This is different from the convention adopted in the WDS Catalogue of reporting the mean position of C-D relative to AB.

3.1 Quadrant determination

As mentioned in Sect. 2, we have used the restricted triple-correlation technique of Aristidi et al. (1997) to try resolving the 180° ambiguity in the θ measurements made from the auto-correlation files and determine the quadrant containing the companion. For each observation, we examined the location on the triple-correlation file of the faintest secondary spot, which corresponded to that of the companion. When the signal-to-noise ratio was good enough, we were able to unambiguously determine the location of this spot and thus resolve the 180° ambiguity. For the couples with the largest separations, we could also see the location of the companion directly on the long integration files. As a result, in Table 1, we are able to give the non-ambiguous angular separation of 119 out of 176 measurements, i.e. 68% of the total (marked with an asterisk in Col 9).

Note that we used a different method for WAK 21CD. This pair belongs to the the quadruple system of ADS 11454 consisting of STF2339AB-CD = HU 322AB + WAK 21CD. With our observations we detected the three components AB, C and D (see Table 1), but we could not resolve the pair A-B (HU 322AB) that is presently too close ($\rho < 0''.1$) for the 102 cm Zeiss telescope. To determine the quadrant of WAK 21CD we computed the bispectrum from our data recorded on tape and managed to restore an image of the triple system AB, C and D, following the procedure described in Prieur et al. (2003). This image and the mean autocorrelation are displayed in Fig. 2. Our observations thus lead to a position angle of 265.5° for WAK 21CD. This is in agreement both with the quadrant published in the last version of the WDS Catalogue, and with the speckle measurements of Scardia et al. (2000) and Balega et al. (2002), that are reported in IC4 (both were made in 1998).

When checking whether those “absolute” θ values were consistent with the values tabulated in IC4, we found a good agreement for all objects, except for ADS 12770, 15950, and 16037. We now discuss the cases of those three objects, using the usual convention of numbering the quadrants from 1 to 4 to indicate the North-East, South-East, South-West and North-West quadrants, respectively.

ADS 12770: our quadrant determination (Q=1) seems robust with a clear contrast between the two secondary peaks of the triple correlation. It is nevertheless in contradiction with the third quadrant reported in IC4, relative to observations made in the V band. Our quadrant determination was made without any filter (i.e. in W), which results in a spectral band close to the R band (see Sect. 3). This may be the origin of the discrepancy, and a quadrant inversion could occur between V and R, since the two stars have a small magnitude difference: $\Delta m_V = 0.1$ mag. according to Germain et al. (1999).

ADS 15950: here also, our quadrant determination (Q=2) seems reliable and was made without any filter, whereas the quadrant of Q=4 reported in IC4 refers to the V band. The difference of magnitude is even smaller than for ADS 12770, with $\Delta m_V = 0.06$ mag. (WDS),

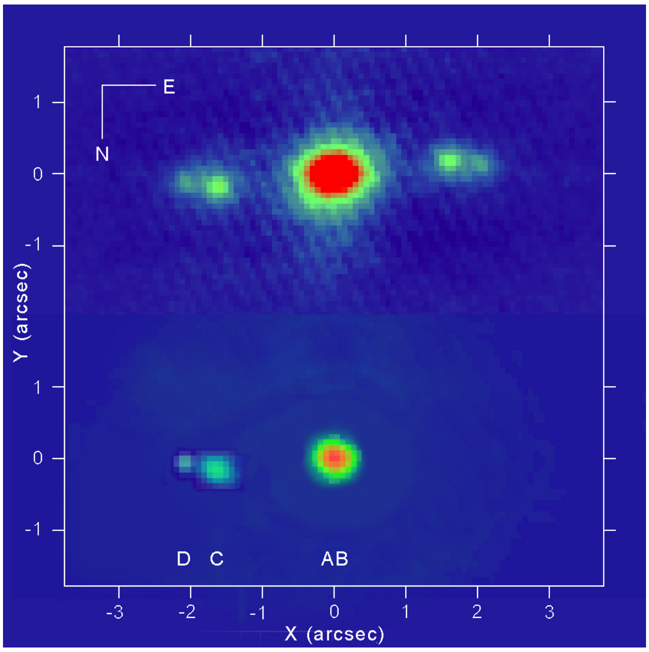

Fig. 2 Triple system (AB, C, D) of ADS 11454: autocorrelation (top) and restored image with bispectral methods (bottom). To improve the clarity of this image, we have subtracted a circular halo that existed around the central component after deconvolution, and whose origin was due to an imperfect matching of the seeing between the object and the reference star.

which could naturally explain a quadrant inversion between V and R.

ADS 16037: in this case, our quadrant determination (Q=2) is not as clear as the others, but the signal-to-noise ratio is still satisfactory. IC4 reports a quadrant Q=4 in disagreement with our determination that was also made without any filter (in W) because of the low luminosity of this object. The magnitude difference is slightly larger in this case, with $\Delta m_V \approx 0.25$ mag and an integrated spectral type F5. Hence a quadrant inversion is less likely, but cannot be excluded. We intend to re-observe this pair as soon as possible, as well as ADS 12770 and 15950, to check our quadrant determinations.

Finally, there is a quadrant discrepancy for ADS 12201 and 14839, when considering the quadrant convention adopted for the orbit computation by some authors (see next Section). Their convention seems doubtful since it is in contradiction with the last observations reported in IC4.

3.2 Comparison with published ephemerides

The $(O - C)$ (Observed minus Computed) residuals of the measurements for the 58 systems with a known orbit of Table 1 are displayed in Table 2 in Cols. 6 and 7 for the separation ρ and position angle θ, respectively. The orbital elements used for computing the ephemerides were retrieved from OC6 and from our last publications (Scardia et al. 2006, 2008a, 2008b). When extracted from OC6, the corresponding bibliographic references are indicated in Col. 3 as they appear in this catalogue, with an asterisk. The ρ values in Col. 5 are the relevant observed separations, taken from Col. 7 of Table 1. They are repeated here for the convenience of the reader, to be able to identify the cases when ρ is small. For ADS 11479, 11584 and 16538, we also give the residuals obtained with our new orbits presented in Sect. 4, for comparison.

We noted a 180° discrepancy of the position angle between our measurements and the published ephemerides for ADS 12201 and 14839 (see Sect. 3.1). This is indicated with the superscript ^{Q} in Col. 7.

The residuals reported in Table 2 were computed with the most recent orbits found in OC6, but for some objects, we also give the $O - C$ values relative to old orbits found in the previous issues of OC6, when they are still valid. This includes ADS 11635AB, 12889AB, 15115, 16373 for which the “old” and “new” orbits lead to comparable residuals. For ADS 11956, we used our last orbit published in Scardia et al. (2008b), that was computed using the PISCO measurement reported in Table 1.

Fig. 3 shows that the residuals are well centered around the origin, with a rather large scatter that can be explained by the (old) age of many orbits. The average values computed with the 63 residuals of Table 2 are $< \Delta\rho_{O-C} >= 0''.00 \pm 0''.09$ and $< \Delta\theta_{O-C} >= -0^\circ.3 \pm 1^\circ.8$. The small values obtained for those offsets provide a new validation of our calibration made with a grating mask (see Paper III), which is thus in good agreement with the measurements made by the other observers.

A very large residual in separation was computed for ADS 13256 with Hopmann (1973)’s orbit: $\Delta\rho_{O-C} = -0''.54$. Unfortunately, the motion seems rectilinear for this object. The arc of orbit is very short and the derivation of valid orbital parameters is still impossible.

Concerning the position angles, the largest absolute values of the residuals were found for ADS 11584, with $\Delta\theta = -6.1^\circ$ (Alzner 2006), and ADS 16538, with $\Delta\theta = -5.3^\circ$ (Baize 1992). We propose new orbital elements for those objects in the next section.

4 Revised orbits for ADS 11479, 11584 and 16538

In this section we present the new orbits we have computed for ADS 11584 and 16538, for which the previously published orbits resulted in large residuals from our measurements. We also computed new orbital elements for ADS 11479 since its orbit has not been revised for more than forty years although numerous observations have been done since.

Table 2 Residuals of the measurements of Table 1 with published orbits (begin.). In col. 3, an asterisk indicates that the references are reported as they appear in the Sixth Catalog of Orbits of Hartkopf & Mason (2008). The other references can be found in Sect. References, at the end of this paper. In col. 7, ^{Q} indicates discrepant quadrants between our measurements and those orbits.

ADS	Name	Orbit	Epoch	ρ(O) (arcsec)	$\Delta\rho$(O-C) (arcsec)	$\Delta\theta$(O-C) (deg.)
10157	STF 2084	Söderhjelm (1999)*	2006.642	1.019	-0.03	0.3
10235	STF 2107 AB	Scardia et al. (2003c)*	2006.680	1.452	0.07	-1.3
10279	STF 2118 AB	Scardia et al. (2002d)*	2006.639	1.067	-0.09	-1.3
10345	STF 2130 AB	Heintz (1981b)*	2006.639	2.360	0.05	1.9
10531	HU 1179	Hartkopf (2000b)*	2006.675	0.247	-0.01	1.7
10598	STF 2173	Heintz (1994a)*	2006.680	0.451	-0.01	0.5
10699	STF 2199	Popovic & Pavlovic (1995d)*	2006.694	2.007	0.09	1.4
10743	HU 1285	Seymour et al. (2002)*	2006.677	0.546	0.01	-0.2
10769	STF 2205	Cvetkovic (2007a)*	2006.696	1.076	-0.03	-0.4
10795	STF 2215	Cvetkovic & Novakovic (2006e)*	2006.677	0.505	0.02	1.2
10912	STF 2244	Heintz (1997)*	2006.680	0.611	0.08	-1.5
11010	BU 1127 Aa-B	Cvetkovic & Novakovic (2006e)*	2006.639	0.775	-0.05	-1.5
11111	STF 2281 AB	Söderhjelm (1999)*	2006.718	0.602	0.00	1.4
”	”	”	2006.721	0.588	-0.01	1.2
11123	STF 2289	Hopmann (1964b)*	2006.694	1.231	-0.01	2.3
11128	HU 674	Seymour et al. (2002)*	2006.677	0.753	0.12	0.2
11186	STF 2294	Luyten (1934a)*	2006.696	1.295	0.10	-0.7
11311	STT 353 AB	Andrade (2005)*	2006.699	0.480	0.00	-0.9
11324	AC 11	Heintz (1995)*	2006.696	0.873	0.03	-0.1
11334	STF 2315 AB	Mason et al. (2004b)*	2006.696	0.642	0.01	0.7
11339	BU 1203	Popovic & Pavlovic (1996b)*	2006.726	0.459	-0.01	-0.6
11468	A 1377 AB	Scardia (1984e)*	2006.677	0.251	0.01	-4.1
11479	STT 359	Symms (1964)	2006.639	0.729	0.01	0.7
”	”	This paper	”	”	−0.00	0.1
11483	STT 358 AB	Heintz (1995)*	2006.675	1.655	0.10	0.8
11579	STF 2367 AB	Pourbaix (2000b)*	2006.743	0.378	0.00	-0.2
11584	STT 363	Alzner (2006)	2006.727	0.431	0.01	-6.1
”	”	This paper	”	”	0.02	−2.9
11635	STF 2382 AB	Mason et al. (2004b)*	2006.675	2.380	-0.03	0.3
”	”	Novakovic & Todorovic (2006e)*	”	”	0.00	0.2
11635	STF 2383 Cc-D	Docobo & Costa (1984b)*	2006.675	2.381	0.02	-0.1
11871	BU 648 AB	Heintz (1994a)*	2006.721	0.898	-0.03	1.5
11897	STF 2438	Hartkopf & Mason (2001a)*	2006.716	0.867	0.03	0.9
11956	STF 2437	Scardia et al. (2008b)	2006.743	0.580	0.00	0.1
12040	STF 2454 AB	Starikova (1982b)*	2006.822	1.326	0.00	0.5
12201	STF 2484	Hopmann (1973b)*	2006.694	2.163	-0.12	0.3^Q
12447	STF 2525	Heintz (1984b)*	2006.677	2.130	0.05	-0.5
12540	MCA 55 Aac	Scardia et al. (2008a)	2006.721	0.359	-0.02	-2.5
12880	STF 2579 AB	Scardia (1983a)*	2006.721	2.666	0.01	-1.0
”	”	Scardia (1983a)*	2006.762	2.647	-0.01	-0.9
12889	STF 2576 AB	Scardia (1981)*	2006.699	2.832	-0.04	-0.9
”	”	Söderhjelm (1999)*	”	”	-0.01	-0.3
12972	STT 387	Mason et al. (2006b)*	2006.724	0.571	0.00	0.1
13256	STF 2613	Hopmann (1973)	2006.727	3.637	-0.54	2.3
13461	STT 400	Heintz (1997)*	2006.699	0.593	0.01	0.1
14073	BU 151 AB	Alzner (1998a)*	2006.790	0.532	-0.01	-0.6
14296	STT 413 Aa-B	Rabe (1948b)*	2006.784	0.876	-0.03	2.7
14499	STF 2737 AB	Zeller (1965)*	2006.869	0.632	0.01	0.5
14783	H1 48	Scardia et al. (2008a)	2006.727	0.229	-0.06	-3.1
14839	BU 163 AB	Fekel et al. (1997)*	2006.727	0.757	0.02	-1.5^Q
15007	STF 2799 AB	Popovic (1987)*	2006.727	1.854	0.12	2.1
15115	HU 371	Scardia et al. (2006)	2006.953	0.255	-0.05	0.9
”	”	Mason et al. (2006b)*	”	”	-0.03	-1.1
15270	STF 2822 AB	Heintz (1995)*	2006.784	1.781	0.06	-2.3
15447	BU 75 AB	Heintz (1996a)*	2006.784	0.906	-0.02	-0.8

Table 2 Residuals of the measurements of Table 1 with published orbits (end).

ADS	Name	Orbit	Epoch	ρ(O) (arcsec)	$\Delta\rho$(O-C) (arcsec)	$\Delta\theta$(O-C) (deg.)
15670	STF 2872 BC	Seymour et al. (2002)*	2006.790	0.829	0.01	-0.2
–	COU 136	Couteau (1999b)*	2006.954	0.485	-0.03	2.4
16185	STF 2934	Heintz (1981a)*	2006.951	1.337	0.14	-0.5
16345	BU 382 AB	Söderhjelm (1999)*	2006.869	0.823	-0.04	0.8
16373	HU 987	Heintz (1984a)*	2006.790	1.110	0.14	-0.5
”	”	Brendley (2007a)*	”	”	0.05	-1.3
16530	HU 994	Docobo (1991e)*	2006.869	0.200	-0.05	2.6
16538	STT 489 AB	Baize (1992)	2006.869	1.094	-0.09	-5.3
”	”	This paper	”	”	−0.02	−2.1
16836	BU 720	Starikova (1982b)*	2006.975	0.554	0.02	-3.8
16877	STT 500 AB	Zulevic (1981)*	2006.975	0.463	0.03	-4.2
16951	A 1242	Ling (2004c)*	2006.976	0.940	0.00	-2.5

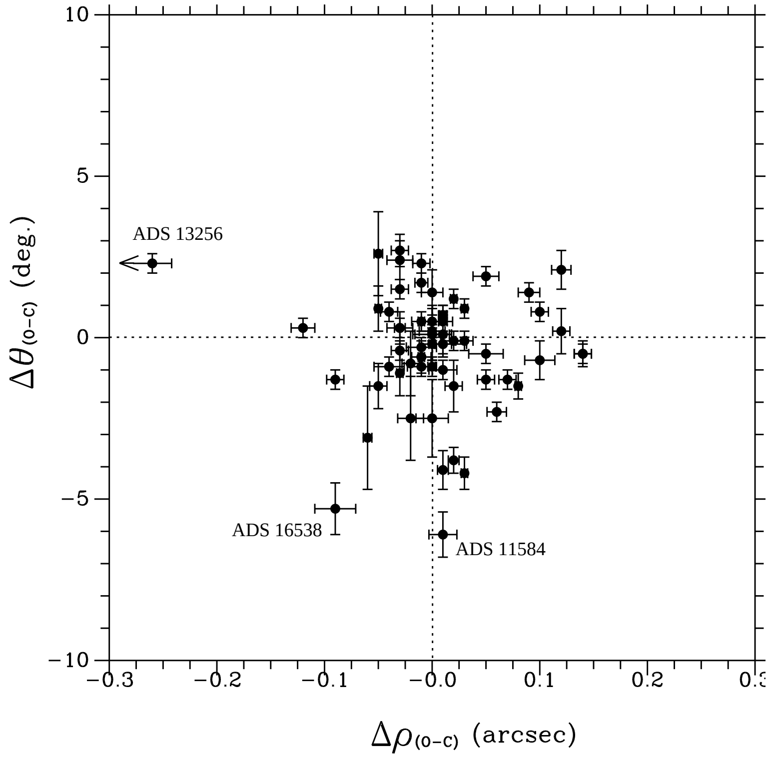

Fig. 3 Residuals of our measurements from the published orbits. The data point of the residual of ADS 13256, computed with Hopmann (1973)'s orbit, lies outside of this frame.

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

The final orbital elements are presented in Table 3. In this table, Ω_{2000} is the position angle of the ascending node, measured in the plane of the sky from north through east, taking the equinox of 2000 as a reference, ω is the longitude of the periastron in the plane of the true orbit, measured from the ascending node to the periastron, in the direction of motion of the companion, i is the inclination of the orbit relative to the plane of the sky, e the eccentricity, T the epoch of periastron passage, P the period, n the mean angular motion, and a is the semi-major axis. The four parameters A, B, F, and G are the Thiele-Innes constants (useful for an easier computation of the ephemerides).

The corresponding $(O-C)$ residuals, restricted to the last observations for reasons of space, are given in Tables 4, 5 and 6 for ADS 11479, 11584 and 16538, respectively. For each measurement, the date in Besselian years is given in Col. 1, and the $(O-C)$ residuals in ρ and θ in Cols. 2 and 3, respectively.

The apparent orbits are shown in Fig. 4 as solid lines and the observational data used for the calculation of the orbital elements are plotted as small crosses. The orientation of the graphs conforms to the convention adopted by the observers of visual binary stars. For each object, the big cross indicates the location of the primary component, and the straight line going through this point is the line of apsides. The sense of rotation of the companion is indicated with an arrow.

The ephemerides for 2008–2015 are presented in Table 7, with the date in Besselian years in Col. 1, the angular separations ρ in Cols. 2, 4 and 6, and the position angles θ in Cols. 3, 5 and 7.

We present some physical parameters derived for those systems from our orbital elements in Table 8. For each object whose name is given in Col. 1 we report its spectral type in Col. 2, the Hipparcos parallax π_{HIP} in Col. 3, the apparent angular extent of the semi major axis a in arcseconds in Col. 4 (from Table 3), the linear size of a in AU in Col. 5, and the total mass of the system $\mathfrak{M}_{\rm total}$ in Col. 6. Both the linear size of a and $\mathfrak{M}_{\rm total}$ were computed from our orbital elements and using the Hipparcos parallax.

4.1 New orbit of ADS 11479 — STT 359

The revision of the orbit of ADS 11479 is mainly justified because the previous orbit is very old (Symms 1964) and we have taken advantage of the numerous measurements obtained by speckle interferometry. Indeed, out of the 257 measurements now available for this object, 132 were obtained since 1964, mostly with speckle techniques. The new orbital elements reported in Table 3 were computed with the analytical method of Kowalsky (1873) followed by the least-squares method of Hellerich (1925). During this computation, it appeared that 13 measurements had to be rejected because they were clearly aberrant. The standard deviations of the residuals are $0''.05$ and $2^\circ.0$ for ρ and θ, respectively.

The total mass of the system derived from our orbit is 5.3 ±3.3 $M_\odot$ (see Table 8), which is in good agreement with the value expected for a system of this spectral type (G9 III).

4.2 New orbit of ADS 11584 — STT 363

The orbital elements reported in Table 3 were derived from the 58 available measurements obtained since 1843. The standard deviations of the residuals are $0''.05$ and $4^\circ.7$ for ρ and θ, respectively.

Table 4 ADS 11479: O-C residuals of our new orbit (after 1995). The symbol ^{P} indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) (arcsec)	$\Delta\theta$ (O-C) (deg.)
1997.537	−0.023	0.6
1997.537	−0.023	0.4
1997.579	−0.013	0.1
1997.601	−0.003	0.0
1997.609	−0.023	−0.5
1997.658	−0.033	−0.6
1997.669	−0.003	0.0
1998.673	0.004^P	0.7^P
1999.512	−0.020	−1.7
1999.512	−0.030	−1.3
1999.550	0.030	0.2
1999.728	0.001	1.0
1999.745	−0.010	0.4
2000.546	−0.023	0.2
2001.417	−0.025	0.5
2001.580	0.024	1.1
2002.460	−0.059	0.4
2002.510	0.011	1.7
2003.598	−0.002	0.9
2004.369	0.016	1.1
2004.640	-0.003^P	0.5^P
2004.694	0.015	0.2
2006.389	−0.009	0.4
2006.639	-0.001^P	0.1^P

Table 5 ADS 11584: O-C residuals of our new orbit (after 1995). The symbol ^{P} indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) (arcsec)	$\Delta\theta$ (O-C) (deg.)
1996.430	0.025	4.5
1996.600	0.051	6.0
1997.540	0.081	9.6
1999.570	0.030	8.8
2000.610	0.040	7.2
2001.470	0.025	3.8
2002.540	0.046	7.4
2002.581	0.016	−0.8
2003.560	0.019	2.1
2004.510	0.014	3.6
2005.630	0.007	0.6
2006.727	0.022^P	-2.9^P

In the last 35 years, the best orbits have been calculated by Zulevic (1975), Baize (1989) and Alzner (1996), with increasing values for the orbital period. Alzner (2006)'s orbit leads to a large residual with our last measurement: $\Delta\theta_{O-C} = -6^\circ.1$. As the declination of ADS 11584 is high (close to 77°), all the measurements had to be carefully corrected for precession effects (which reached 4° during the 160 year time-range of the observations). As the angular sepa-

Table 3 New orbital elements of ADS 11479, 11584 and 16538.

ADS	Ω_{2000} (deg.)	ω (deg.)	i (deg.)	e	T (yr)	P (yr)	n (deg./yr)	a (arcsec)	A (arcsec)	B (arcsec)	F (arcsec)	G (arcsec)
11479	10.0	197.7	119.9	0.8393	1929.081	219.3	1.64129	0.425	−0.40992	−0.00687	0.09220	0.22120
	±1.2	±2.1	±2.0	±0.0066	±0.54	±8.8	±0.066	±0.014				
11584	159.7	55.9	78.3	0.890	1987.038	641.9	0.56083	0.950	−0.55487	0.03516	0.70033	−0.37422
	±1.5	±4.8	±1.7	±0.057	±0.72	±506.0	±0.44	±0.244				
16538	90.3	90.0	30.0	0.5968	1934.573	162.8	2.21147	0.810	−0.70147	−0.00367	0.00424	−0.80999
	±4.9	±4.4	±3.0	±0.0067	±0.35	±2.8	±0.038	±0.050				

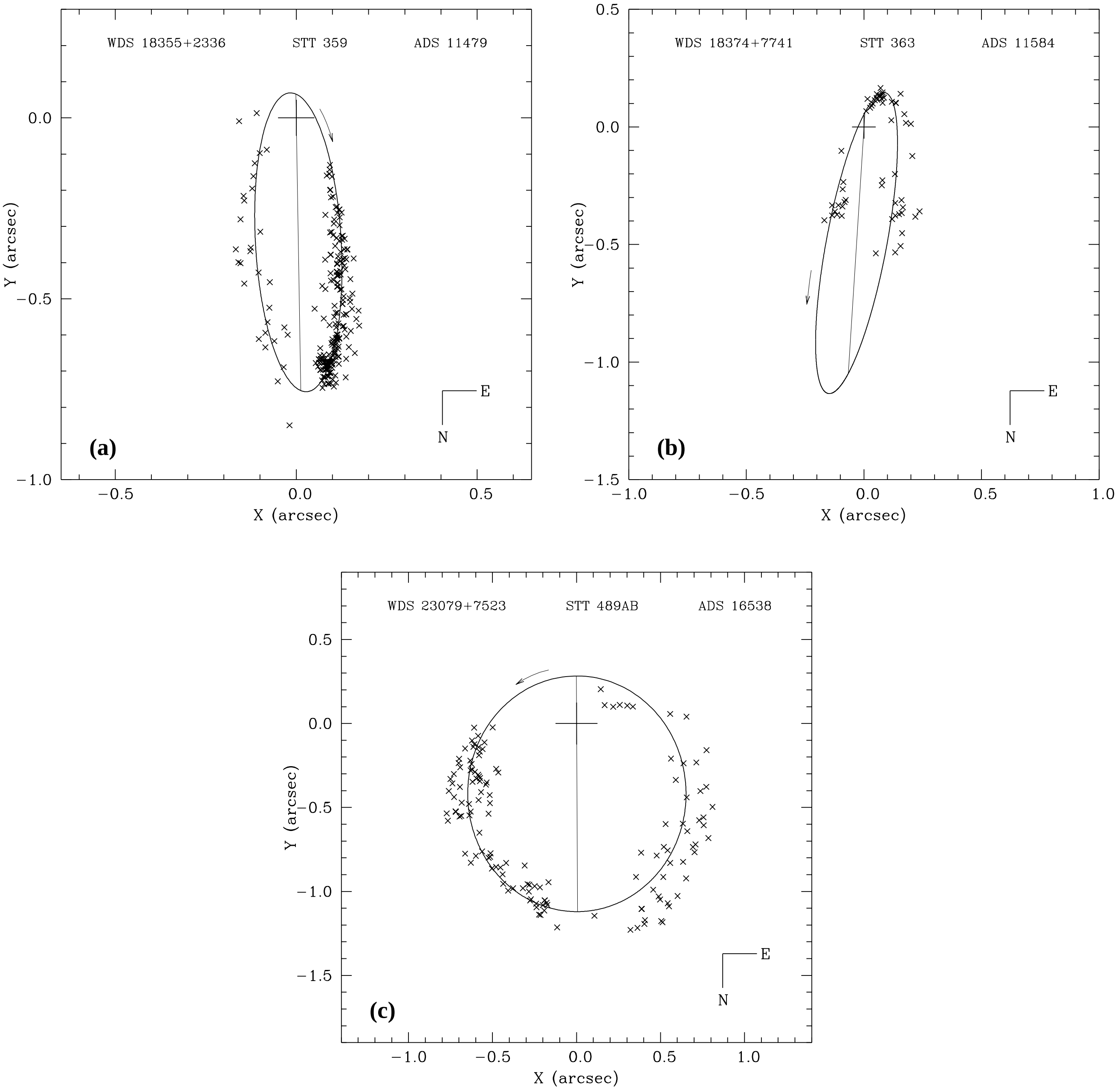

Fig. 4 New orbits of ADS 11479 (a), ADS 11584 (b) and ADS 16538 (c).

Table 6 ADS 16538: O-C residuals of our new orbit (after 1995). The symbol ^{P} indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) (arcsec)	$\Delta\theta$ (O-C) (deg.)
1996.760	-0.045	-0.4
1996.940	0.075	4.2
1997.660	-0.088	-1.6
1998.770	-0.022	3.5
1998.774	-0.011	-0.8
1998.790	-0.002	-1.0
1999.690	-0.095	0.4
2000.690	0.022	-0.2
2002.770	-0.034	0.2
2004.974	-0.027^P	-0.9^P
2005.750	0.020	-1.8
2006.869	-0.018^P	-2.1^P

Table 7 New ephemerides of ADS 11479, 11584 and 16538.

	ADS 11479		ADS 11584		ADS 16538	
Epoch	ρ (arcsec)	θ (deg.)	ρ (arcsec)	θ (deg.)	ρ (arcsec)	θ (deg.)
2008.0	0.733	5.3	0.427	340.1	1.114	353.9
2009.0	0.735	5.2	0.441	340.4	1.116	354.7
2010.0	0.737	5.0	0.454	340.6	1.117	355.5
2011.0	0.739	4.9	0.467	340.8	1.118	356.3
2012.0	0.741	4.7	0.480	340.9	1.119	357.1
2013.0	0.743	4.6	0.492	341.1	1.119	357.9
2014.0	0.744	4.5	0.504	341.3	1.120	358.7
2015.0	0.746	4.3	0.516	341.4	1.120	359.5

Table 8 Physical parameters (a and $\mathfrak{M}_{\text{total}}$) derived from the new orbital elements.

Name	Sp. type	π_{HIP} (mas)	a (″)	a (AU)	$\mathfrak{M}_{\text{total}}$ M$_\odot$
ADS 11479	G9 III	6.70	0.425	63	5.3
		±1.38	±0.014	±13	±3.3
ADS 11584	F0 IV	7.94	0.95	120	4.2
		±0.51	±0.24	±31	±7.3
ADS 16538	G2 III	13.8	0.81	59	7.6
		±0.4	±0.05	±4	±1.6

ration is smaller than $1''$, this couple is difficult to observe and the measurements are very scattered. Some of them are clearly aberrant. Even the measurement of 1991.25 made by Hipparcos ($\rho = 0''.14$, $\theta = 316^\circ.8$) is doubtful. Nearly all the most recent observations are from Alzner, but the angular position measurements are rather scattered.

Convergence was difficult to obtain, and the weighting scheme appeared crucial in the process. This explains why our orbit is rather different from Alzner's, with a longer period ($P = 642$ yr instead of $P = 405$ yr for Alzner's orbit) and a larger eccentricity. The total mass derived from our elements of 4.2 M$_\odot$ (Table 8) is in agreement with the expected value for a system of this spectral type (F0 IV). Unfortunately this result is affected by a very large uncertainty (±7.3 M$_\odot$!), that results from the large uncertainty of the period and of the major axis, due to an incomplete coverage of the orbit (see Fig. 4b). Using the formula that we have obtained for luminosity class IV in Scardia et al. (2008b), we find a dynamical parallax of $\pi_{\text{dyn}} = 8.50$ mas, in good agreement with the Hipparcos measurement.

Even though we have obtained convergence on the orbital elements and thus derived their uncertainties, and although the systemic mass is in agreement which the expected mass for a system of this spectral type, the orbit of ADS 11584 should still be considered as badly determined, especially its period and its semi-major axis.

4.3 New orbit of ADS 16538 — STT 489 AB

π Cephei (HR 8819, HD 218658, ADS 16538) is a multiple system, whose main system A-B is constituted of a bright star with a faint companion. The resulting large magnitude difference makes measurements difficult to perform. It was first discovered as a visual binary by Otto Struve in 1843 (hence the name STT 489 AB for the visual binary), and later the primary star (G2 III according to SIMBAD whereas the WDS reports G0 IV) was found to be a spectroscopic binary with the Lick 0.91 m refractor by Campbell (1901). The first spectroscopic orbit of the Aa-Ab system was determined by Harper (1925) and recently improved by Scarfe et al. (1983).

The orbit of STT 489 AB could have been well constrained by the measurements made during the periastron passage of 1934. Unfortunately, the observations were difficult to perform at that time (with $\theta \approx 0''.3$) and perturbed by World War II, at least in Europe where very few astronomers could observe. The most recent orbit was computed by Baize (1992) with the measurements made until 1989. The last measurements lead now to negative residuals in ρ and θ. Note that Baize did not report any equinox value, because he probably did not perform any correction for precession effects.

From the 155 measurements obtained since 1846, we derived the orbital elements of STT 489 AB presented in Table 3. The standard deviations of the residuals are $0''.10$ and $3^\circ.4$ for ρ and θ, respectively. Those values are those expected for a sub-arcsecond couple. A few observations had to be discarded, but convergence was easy to achieve. As already mentioned by Muller (1951) and Baize (1992) there is a systematic difference in separation for the measurements made before and after the periastron passage of 1934. In average, the former are larger and more scattered than the latter.

Using the Hipparcos parallax value revised by Gatewood et al. (2001) of $\pi_{HIP} = 13.8 \pm 0.41$ mas, we obtain a total system mass of 7.6 ±1.6 $M_\odot$. This value is in good agreement with the value of 8.8 ±0.9 $M_\odot$ derived by Gatewood et al. (2001), who performed a detailed study of this system that combined spectroscopic and visual data.

5 Conclusion

In the first semester of 2006, we performed 175 observations of 169 visual binaries with PISCO in Merate. When adding those made since 2004, the total reaches 1078 observations, which is more than twice the number of binary observations made with PISCO on the 2-meter Bernard Lyot telescope of *Pic du Midi* during the period 1993–1998. The new exploitation of PISCO in Merate has thus already provided a significant contribution to the measurements of close visual binary stars.

The measurements reported here have already been used to revise the orbits of ADS 11956 (Scardia et al., 2008b) and of ADS 11479, 11584 and 16538, whose elements are presented in this paper. We hope that our measurements will be useful to the astronomical community and help to improve the accuracy of many other orbits in the future.

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