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Speckle observations with PISCO in Merate: IV. Astrometric measurements of visual binaries in 2005

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We present relative astrometric measurements of visual binaries made during the second semester of 2005, 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. The purpose of this long term program is to improve the accuracy of the orbits and determine the masses of the components.
We performed 130 new observations of 120 objects, with most of the angular separations in the range $0''.1$–$4''$, and with an average accuracy of $0''.01$. Most of the position angles could be determined without the usual 180° ambiguity with the application of triple-correlation techniques, and their mean error is $0^\circ.8$. We have found a possible new triple system: ADS 11077.
The measurements of the closest binaries were made with a new data reduction procedure, based on model fitting of the background of the auto-correlations. As this procedure proved to be very efficient, we have re-processed the old observations of close binaries made with PISCO in Merate since 2004. We thus improved 20 measurements already published and obtained 7 new measurements for observations that were previously reported as "unresolved".
We finally present revised orbits for ADS 684, MCA 55Aac (in the Beta 1 Cyg–Albireo multiple system) and ADS 14783 for which the previously published orbits led to large residuals with our measurements and for which the new observations made since their computation allowed a significant improvement of those old orbits. The sum of the masses that we derived for those systems are consistent with the spectral type of the stars and the dynamic parallaxes are in good agreement with the parallaxes measured by Hipparcos.

1 Introduction

This paper is the fourth of a series (Scardia et al. 2005a, 2005b, 2007; Papers I, II and III herein), 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. More information about the context and the purpose of this program can be found in Paper I.

This paper presents the results of the observations performed during the second semester of 2005. In Sect. 2, we briefly describe our sample, the instrumental setup and the reduction procedure with a short presentation of the new method we have developed for processing the auto-correlation of the closest binaries of this sample. The astrometric measurements derived from our observations of the second half of 2005 are presented and discussed in Sect. 3. Since the new processing method proved to be very efficient, we have re-processed the old observations of the closest binaries (with $\rho < 0''.25$) made with PISCO from 2004. The corresponding new measurements are given and discussed in Sect. 4. Finally, in Sect. 5 we present revised orbits for ADS 684, 14783 and MCA 55Aac, partly derived from those observations and derive some estimates of the component masses.

2 Observations and data reduction

As stated in Paper I, the purpose of our long term program is to observe all the visual binaries accessible with PISCO on the Zeiss telescope in Merate, for which new measurements are needed to improve their orbits. This program started a decade ago when PISCO was used with the 2-m telescope of Pic du Midi observatory, but since the installation of PISCO in Merate in November 2003, the reduction of the telescope

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size by a factor of two has forced some changes on the possible targets. Our present sample consists of visual binaries with the following characteristics, which are imposed by instrumental or atmospheric limitations:

- declination north of $-5°$,
- brighter than 9.5 magnitude in V,
- magnitude difference less than 4,
- angular separation smaller than $\approx 4''$.

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. 2. It shows that the closest binaries with $\rho \lesssim 2''$ are the most numerous in our sample. Note that for this paper we have managed to measure the wide binary ADS 1860 Aa-C with $\rho = 7\farcs3$, but this is an exception. Indeed conventional CCD detectors are sufficient and more appropriate for measuring large binaries with $\rho > 4''$.

The observations presented here were carried out with the PISCO speckle camera with the ICCD detector (CCD intensified with a micro-channel plate) belonging to Nice University. 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, to compute the mean auto-correlation with Worden's (1977) method (which subtracts most part 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 why speckle position angle measurements of binaries have a well-known 180-degree ambiguity. This ambiguity can be solved 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 then 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 this work we improved this method for the closest binaries, i.e. when the secondary peaks are superimposed upon the central background pattern. We first obtained a template of this pattern from observations of unresolved stars. We could then fit this template to any other auto-correlation file and use the corresponding scaled version of the template to remove most of the background, even very close to the centre. Although this background has a theoretical dependence on the seeing, it appeared that, surprisingly, a single template led to satisfactory results for all the close binaries that we have processed. This must be due to a good homogeneity of our observations. We display in Fig. 1 an example of the processing of the auto-correlation of ADS 6185, which has led to a new detection, with $\rho = 0\farcs085$ (see Sect. 4). The subtraction of the central pattern has revealed the two faint secondary peaks that were previously buried in this image (compare the intensity scale of the slice AB before and after processing in Fig. 1). As we have found this method very efficient, we have re-processed in this way the old observations of the close binaries made with PISCO in Merate. The results are described in Sect. 4.

3 Astrometric measurements of the second semester of 2005

The astrometric measurements of the observations made during the second semester of 2005 are displayed in Table 1. The designation of the binary is given in the first 3 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 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 R, V and B filters that we have used for those observations are listed in Table 1 of Paper III. Note that some objects like ADS 1504, 11397 and 12298 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 were estimated by adding quadratically the calibration errors to the standard deviations of series of measurements obtained with the same data sets (see Sect. 2). The smallest (one-sigma) errors for the angular separation (Col. 8) were estimated at $0\farcs003$ for close pairs (i.e., $\rho < 1''$) which corresponds to 0.1 pixel in the elementary frames and at 0.05% of ρ for wide pairs (i.e., $\rho > 1''$), on the basis of the uncertainties coming from the determination of the centres of the auto-correlation peaks and those affecting the scale calibration. Similarly, the minimum (one-sigma) errors for the position angle (Col. 10) were estimated at $0\fdg3$. The average values of the errors displayed in this table are $0\farcs013 \pm 0\farcs006$ and $0\fdg8 \pm 0\fdg9$ for ρ and θ, respectively. The validity of our error determination was discussed in Paper III.

The position angles presented in Col. 9 follow the standard convention with the North corresponding to $\theta = 0°$ and the East to $\theta = 90°$. Those angles were measured on the auto-correlation functions, which leads to an ambiguity of 180°. When the triple correlation files allowed us to solve this ambiguity (see Sect. 2 and 3.1), an asterisk was added

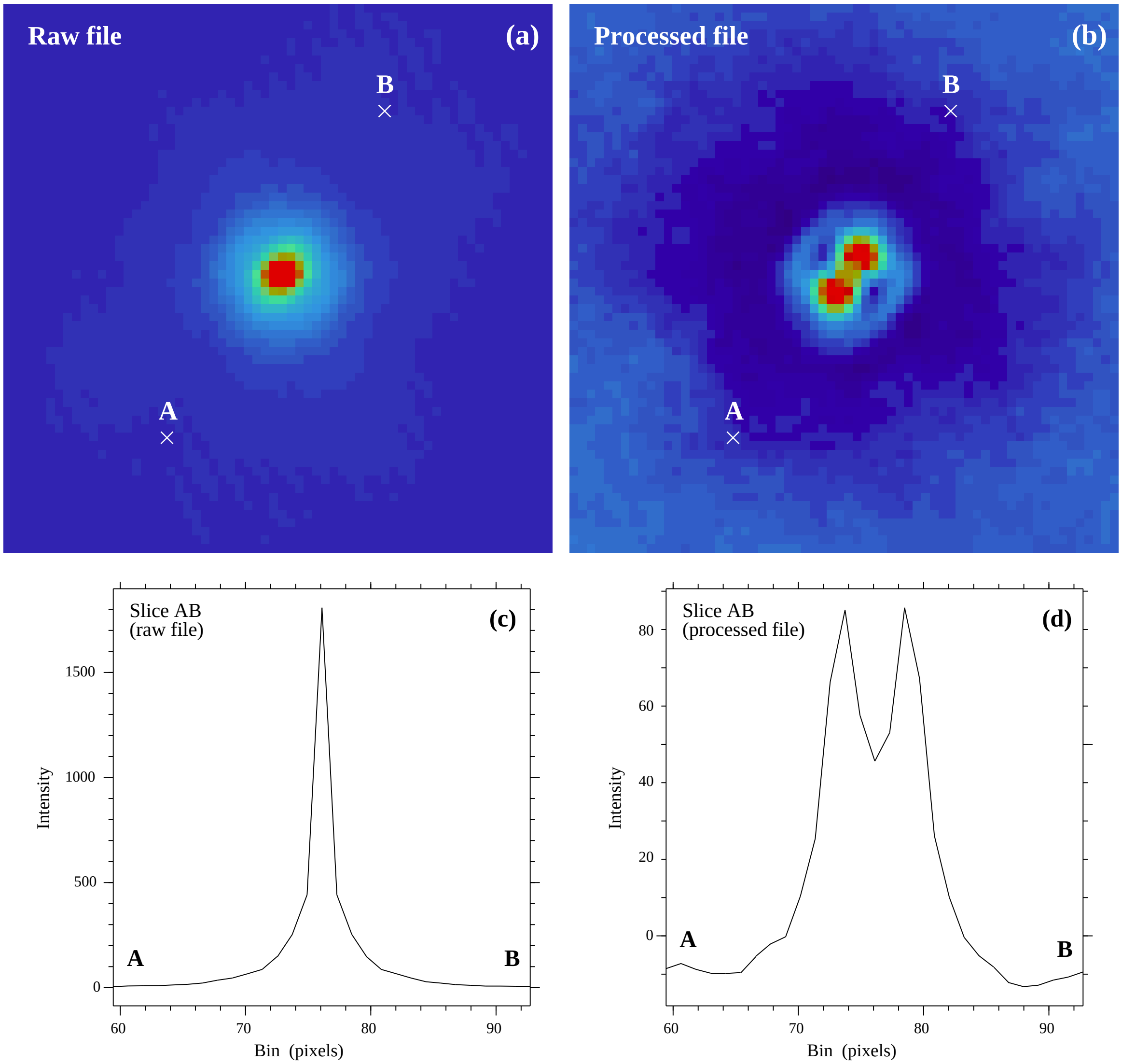

Fig. 1 (online colour at: www.an-journal.org) Subtraction of the central background pattern from the auto-correlations by fitting a model obtained with unresolved objects. Example of direct output (*b*) obtained from the auto-correlation (*a*) of ADS 6185 ($\rho = 0\farcs085$), with the corresponding slices going through the points A and B in (*c*) and (*d*) for the raw and processed files, respectively.

in Col. 9 to indicate that our determination is absolute. Otherwise, we used the quadrant value of the "Fourth Catalogue of Interferometric Measurements of Binary Stars" (Hartkopf et al. 2007, hereafter IC4). There is only one exception for the new component found for ADS 11077 AB, for which the quadrant could not be determined by any of those means.

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 2007), hereafter OC6. The residuals derived from the corresponding ephemerides will be discussed in Sect. 3.2.

We have found a possible new companion for ADS 11077 AB with a separation of $\rho = 0\farcs23$. (see Table 1). This requires new observations to confirm its existence, since to our knowledge this companion has never been mentioned in the literature.

3.1 Quadrant determination

As mentioned in Sect. 2, we have used the restricted triple-correlation technique of Aristidi et al. (1997) to solve 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 solve the 180° ambiguity. This occurred in 73 out of 130 observations, i.e. 56% of the total (marked with an asterisk in Col. 9 of Table 1). When checking whether those "abso-

Table 1 Measurements of observations between July and December 2005 (begin).

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	ρ (arcsec)	σ_ρ (arcsec)	θ (deg.)	σ_θ (deg.)	Orb.	Notes
00093+7943	STF 2	102	2005.897	R	20	0.800	0.008	19.0	0.9	1	
”	”	”	2005.935	R	20	0.822	0.008	18.4	0.3	1	
00116+5558	STF 7	143	2005.897	R	20	1.305	0.012	210.4	0.8	0	
”	”	”	2005.935	R	20	1.315	0.008	210.9	0.3	0	
00318+5431	STT 12	434	2005.900	R	10	0.310	0.003	201.9	0.4	1	
”	”	”	2005.900	B	10	0.315	0.005	202.2	0.8	1	
00416+2438	WRH 28	–	2005.886	R	10	0.066	0.012	302.1	6.5	1	
00444+3337	STF 55	618	2005.900	R	20	2.221	0.011	330.0*	0.3	0	
00480+5127	STF 59AB	659	2005.886	R	20	2.269	0.011	148.0*	0.6	0	
00527+6852	STF 65	710	2005.886	R	20	3.157	0.016	39.5*	0.3	0	
00550+2338	STF 73AB	755	2005.886	R	20	0.968	0.008	317.4*	0.3	1	
01213+1132	BU 4AB	1097	2005.900	R	20	0.578	0.008	109.0*	0.4	1	
01499+8053	STT 34	1411	2005.900	R	10	0.499	0.014	106.0	1.0	1	
01554+7613	STF 170	1504	2005.900	R	20	3.162	0.016	242.8	0.3	0	
”	”	”	2005.900	W	20	3.138	0.019	242.8*	0.3	0	
02291+6724	STF 262Aa-C	1860	2005.900	R	20	7.339	0.037	115.5*	0.3	0	
02291+6724	STF 262Aa-B	1860	2005.900	R	20	2.779	0.014	230.1*	0.3	1	
03344+2428	STF 412AB	2616	2005.900	R	10	0.712	0.005	354.7	0.3	1	
14531+7811	HU 908AB	9445	2005.505	R	20	1.521	0.013	238.2*	0.3	0	
15396+7959	STF1989	9769	2005.505	R	10	0.675	0.004	25.0	0.5	1	
”	”	”	2005.506	R	20	0.662	0.008	24.9*	1.9	1	
15413+5959	STF1969	9756	2005.536	R	20	0.925	0.008	27.4*	0.3	1	
15416+1940	HU 580AB	9744	2005.536	V	10	0.154	0.004	255.8	2.1	1	
”	”	”	2005.538	V	10	0.154	0.006	258.3	2.7	1	
15427+2618	STF1967	9757	2005.536	R	10	0.716	0.004	113.5*	0.3	1	
15432+1340	BU 619	9758	2005.536	R	10	0.654	0.004	1.3*	0.7	0	
15440+2220	COU 106	–	2005.538	R	20	0.329	0.015	95.3*	1.8	0	
15568+1229	STF1988	9850	2005.538	R	20	1.915	0.017	250.5*	0.5	0	
16009+1316	STT 303AB	9880	2005.538	R	20	1.520	0.023	171.9*	0.3	0	
16133+1332	STF2021Aa-B	9969	2005.596	R	20	4.065	0.020	355.3*	0.3	1	
16231+4738	STF2047	10038	2005.607	R	20	1.818	0.022	324.7*	0.3	0	
16238+6142	CHR 138Aa	10052	2005.604	R	20	0.998	0.008	351.1*	0.6	0	
16279+2559	STF2049	10070	2005.536	R	20	1.138	0.008	195.2*	0.5	0	
16289+1825	STF2052AB	10075	2005.536	R	20	2.142	0.013	121.5*	0.3	1	
16309+0159	STF2055AB	10087	2005.536	V	20	1.426	0.008	33.6*	0.6	1	
16309+3804	STF2059	10093	2005.607	R	20	0.449	0.014	188.5	2.9	0	
16326+4007	STT 313	10111	2005.604	R	20	0.933	0.008	131.2*	0.4	0	
16362+5255	STF2078AB	10129	2005.604	R	20	3.148	0.017	104.3*	0.3	0	
16541+0826	HEI 857	–	2005.607	R	20	0.541	0.010	143.2	0.9	0	
16564+6502	STF2118AB	10279	2005.604	R	20	1.094	0.008	67.0*	0.4	1	
16581+1509	STT 319	10277	2005.607	R	20	0.879	0.008	64.7*	0.9	0	
17053+5428	STF2130AB	10345	2005.604	R	20	2.342	0.012	12.8*	0.3	1	
17131+5408	STF2146AB	10410	2005.661	R	20	2.672	0.013	224.1*	0.3	0	
17246+1536	STF2160	10528	2005.607	R	20	3.830	0.019	65.7	0.3	0	
17266+3546	STF2168	10558	2005.604	R	20	2.294	0.011	201.7*	0.3	0	
17320+0249	STT 331AB	10614	2005.664	R	20	1.022	0.008	350.3	2.1	0	
17434+3357	HO 560	10742	2005.607	R	20	1.307	0.008	264.2	0.3	0	
17506+0714	STT 337	10828	2005.662	R	20	0.526	0.015	166.9*	1.0	1	
17541+2949	AC 9	10880	2005.662	R	20	1.107	0.008	240.8	0.5	0	
17571+4551	HU 235	10934	2005.662	R	20	1.603	0.020	283.1*	0.7	0	
18070+3034	–	11077	2005.708	R	20	0.228	0.015	50.2	3.3	0	New comp., faint.
18070+3034	AC 15AB	11077	2005.708	R	20	0.851	0.019	299.6*	0.7	1	Very faint
18096+0609	STF2283	11110	2005.708	R	20	0.613	0.019	57.1*	1.8	0	
18118+3327	HO 82AB-C	11149	2005.735	R	20	0.701	0.023	217.4*	1.2	0	
18121+2739	STF2292	11155	2005.604	R	20	0.901	0.014	273.4	1.0	0	
18126+3836	BU 1091	11170	2005.708	R	20	0.712	0.019	322.2	1.1	0	

Table 1 Measurements of observations between July and December 2005 (cont.).

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	ρ (arcsec)	σ_ρ (arcsec)	θ (deg.)	σ_θ (deg.)	Orb.	Notes
18238+5139	ES 187AB	11328	2005.708	R	20	2.586	0.013	205.6	0.3	0	
18278+2442	STF2320	11373	2005.735	R	20	1.105	0.008	359.1*	0.5	0	
18295+2955	STF2328AB	11397	2005.735	R	20	3.709	0.025	71.4	0.3	0	
”	”	”	2005.735	W	20	3.670	0.018	71.6*	0.3	0	
18458+3431	STF2390	11669	2005.774	R	20	4.189	0.021	155.2*	0.3	0	
18469+5920	STF2410	11697	2005.708	R	20	1.714	0.015	86.6	0.3	0	
18472+3125	STF2397	11685	2005.774	R	20	3.919	0.023	266.7*	0.3	0	
18540+3723	BU 137AB	11811	2005.793	R	20	1.534	0.017	161.6*	0.3	0	
18549+3358	STT 525 AB	11834	2005.776	R	20	1.760	0.017	128.9*	0.6	0	
18576+3209	A 260	11879	2005.793	R	20	0.892	0.013	244.8	0.6	0	
18581+4711	AG 366	11899	2005.708	R	20	1.500	0.022	192.0	1.2	0	
18594+2936	STF2430	11914	2005.787	R	20	1.549	0.027	186.9	0.7	0	
19019+1910	STF2437	11956	2005.662	R	20	0.585	0.011	12.1	1.2	0	
19037+3545	STF2448	12002	2005.774	R	20	2.465	0.012	191.3	0.4	0	
19042+3245	BRD 4	12008	2005.793	R	20	2.544	0.013	310.5	0.3	0	
19055+3352	HU 940	12033	2005.793	R	20	0.540	0.011	194.7	1.2	1	
19070+1104	HEI 568	–	2005.662	R	10	0.291	0.008	279.5*	0.7	0	
”	”	”	2005.774	R	10	0.302	0.009	278.4*	0.7	0	
19078+3856	STF2469AB	12075	2005.820	R	20	1.240	0.009	124.8*	0.4	0	
19079+2948	STF2466AB	12071	2005.820	R	20	2.394	0.014	102.4*	0.3	0	
19160+1610	STT 368AB	12236	2005.735	R	20	1.151	0.008	218.2*	0.3	0	
19186+2157	STF2499	12298	2005.787	W	20	2.591	0.013	323.9*	0.3	0	
19252+3708	HJ 1395AB	12427	2005.820	R	20	2.847	0.014	63.3	0.3	0	
19269+1204	A 1181	12452	2005.735	R	20	0.698	0.017	199.3*	0.7	0	
19307+2758	MCA 55Aac	12540	2005.820	V	10	0.382	0.003	109.7*	0.3	1	
19346+1808	STT 375	12623	2005.793	R	20	0.603	0.008	185.1	0.8	0	
19411+1349	KUI 93	–	2005.820	R	10	0.191	0.011	133.9*	1.3	1	
19438+3819	STT 384AB	12851	2005.736	R	20	1.047	0.008	196.5*	0.8	0	
19450+4508	STF2579 AB	12880	2005.774	R	20	2.646	0.013	221.0*	0.3	1	
19540+1518	STF2596	13082	2005.774	R	20	1.979	0.010	300.7*	0.3	0	
19594+3206	A 378	13212	2005.787	R	20	0.931	0.008	293.0	0.8	0	
20043+3033	STF2626	13329	2005.793	R	20	1.016	0.021	128.2	0.7	0	
20126+0052	STF2644	13506	2005.774	R	20	2.663	0.013	206.5*	0.3	0	
20137+1609	STF2651	13542	2005.736	R	20	1.053	0.008	278.9	0.3	0	
20198+4522	STT 406	13723	2005.774	R	10	0.405	0.003	103.7*	0.3	1	
20293+3731	WEI 35AB	13909	2005.736	R	20	4.044	0.020	213.8*	0.3	0	
20449+1219	STF2723AB	14233	2005.883	R	20	1.037	0.014	134.1*	0.8	0	
20450+1244	BU 64AB	14238	2005.883	R	20	0.643	0.011	350.8	1.0	1	
20481+2727	BU 66	14312	2005.774	R	20	1.069	0.014	168.6	0.4	0	
20486+5029	BU 366AB	14331	2005.820	R	20	1.482	0.008	129.7*	0.5	0	
20487+5155	STF2732	14336	2005.820	R	20	4.223	0.021	72.0*	0.3	0	
21068+3408	STF2760 AB	14645	2005.774	R	20	4.204	0.021	31.6*	0.3	0	
21103+4359	STF2773AB	14711	2005.820	R	20	3.237	0.024	112.7*	0.3	0	
21110+0933	STF2765AB	14715	2005.883	R	20	2.782	0.014	79.3	0.3	0	
21137+6424	H 1 48	14783	2005.886	R	10	0.176	0.003	237.3	1.8	1	
”	”	”	2005.886	V	10	0.174	0.003	236.1	1.8	1	
21145+1000	STT 535AB	14773	2005.919	R	10	0.240	0.005	28.2	0.3	1	
21194+3814	HO 286	14859	2005.886	V	10	0.160	0.003	237.3	6.4	0	
21214+0253	STT 435	14894	2005.883	R	20	0.684	0.014	238.0	1.0	0	
21330+2043	STF2804AB	15076	2005.883	R	20	3.251	0.016	356.4*	0.3	0	
21352+2124	BU 74	15109	2005.886	R	20	1.025	0.008	334.8	0.7	0	
21426+1900	HO 165AB	15234	2005.919	R	20	0.733	0.008	61.2*	0.4	0	
21469+0051	STF2825	15313	2005.935	R	20	0.480	0.008	148.0	2.5	0	
21523+6306	STF2845AB	15417	2005.886	R	20	1.957	0.011	173.3*	0.3	0	
22044+1339	STF2854	15596	2005.820	R	20	1.727	0.011	83.3*	0.3	0	

Table 1 Measurements of observations between July and December 2005 (end.).

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	ρ (arcsec)	σ_ρ (arcsec)	θ (deg.)	σ_θ (deg.)	Orb.	Notes
22058+0452	STF2856	15614	2005.935	R	20	1.220	0.013	195.1	0.4	0	
22071+0034	STF2862	15639	2005.935	R	20	2.535	0.015	95.8	0.3	0	
22202+2931	BU 1216	15843	2005.883	R	20	0.874	0.010	278.7	1.0	0	
22218+6642	STF2903	15881	2005.886	R	20	4.136	0.021	95.9*	0.3	0	
”	”	”	2005.886	V	20	4.138	0.021	96.4*	0.3	0	
22288-0001	STF2909	15971	2005.899	R	20	1.912	0.010	175.3*	0.4	1	
22302+2228	HU 388	15992	2005.883	R	20	0.505	0.008	58.0	0.7	1	
22400+0113	A 2099	16157	2005.935	R	20	0.760	0.012	161.8	0.5	1	
22409+1433	HO 296AB	16173	2005.951	R	10	0.203	0.003	282.2	0.8	1	
22478-0414	STF2944AB	16270	2005.897	R	20	1.913	0.029	297.9	0.8	1	
22552-0459	BU 178	16365	2005.899	R	20	0.660	0.008	323.4*	1.5	1	
”	”	”	2005.900	R	10	0.663	0.007	321.9	0.3	1	
23050+3322	STF2974	16496	2005.820	R	20	2.657	0.013	165.3*	0.5	0	
23103+3229	BU 385AB	16561	2005.821	R	20	0.654	0.017	86.5*	0.3	0	
23133+2205	STF2990AB	16602	2005.886	R	20	2.514	0.022	56.1*	0.4	0	
23208+2158	STT 494	16686	2005.897	R	20	3.236	0.016	81.7	0.3	0	
23277+7406	STF3017AB	16775	2005.900	R	20	1.272	0.013	20.8*	0.4	0	
23324+1724	STF3023	16821	2005.900	R	20	1.738	0.011	280.2*	0.5	0	
23595+3343	STF3050AB	17149	2005.900	R	20	2.149	0.011	333.0*	0.3	1	

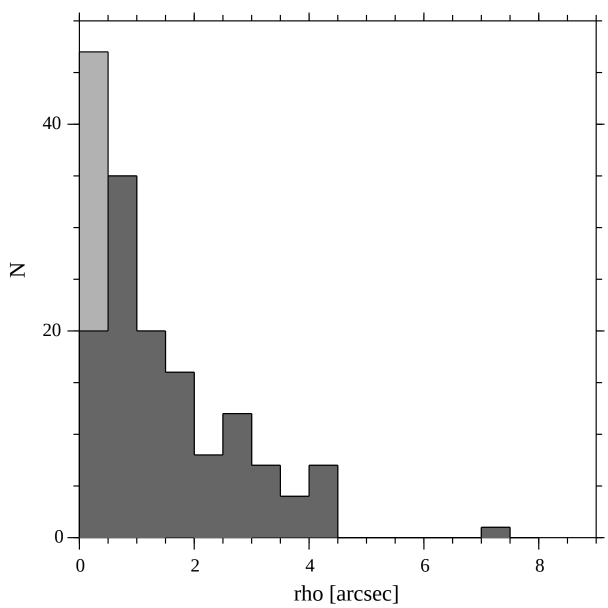

Fig. 2 Histogram of the angular separations of the measurements reported in this paper: new observations (2nd semester of 2005) in dark grey, and re-processed old observations of close binaries in light grey.

lute” θ values were consistent with the values tabulated in IC4, we found a good agreement for all objects, except for COU 106, KUI 93, ADS 710, 1097 and 10052.

COU 106: Our quadrant determination seems robust with a clear contrast between the two secondary peaks of the triple correlation. There is no apparent reason for the quadrant inconsistency.

ADS 10052: Here also, our quadrant determination seems reliable. Note that in IC4 there is a series of observations reported for the period 1978–1996 in the fourth quadrant which is in agreement with our determination. Therefore we think that the values of θ in the range 174–154° for the period 1986–1990 in the WDS catalog (Mason et al. 2007) have been reduced to a wrong quadrant.

KUI 93: Our determination seems also reliable in this case, with a quadrant of II. The situation is rather confused in IC4 and in the WDS. A quadrant of II is reported for the year 1934 in the WDS Catalog and for the period 1949–1968 in IC4. Then the situation changes suddenly, and from 1976 to 2001 a quadrant of IV is reported in both catalogs, except for one observation (made in 1998 by our group, Scardia et al. 2000). This inversion cannot be explained by the orbital motion since the period is estimated between 60 and 70 years in the orbits of Docobo & Ling (2000, 2005) who assumed a quadrant of IV. This problem may be caused by the similarity of the brightnesses of the two components. Indeed the difference of their magnitudes is only $\Delta m_V = 0.06$, with a spectral type of B5V for both components. Furthermore the A component is variable and classified as “Algol-Type” in the OC6 notes. Hence the observers may obtain different quadrant values according to the epoch and the filters they use.

ADS 710: In this case our determination of the quadrant is not as clear as the others, but it looks still satisfactory. There is also some confusion in the literature: while the WDS Catalog reports $\theta = 219°$ for the year 1997, the IC4 always reports θ in the first quadrant between 1991 and 1997, in accordance with our determination, except for an observation of 1991.73 (referenced as TYC2002b in IC4). The magnitude difference of the two components is only $m_V = 0.02$ (with a global spectral type of A2) which naturally explains the difficulty of determining the right quadrant.

ADS 1097: Our determination of the quadrant is rather clear here and a quadrant discrepancy is observed between the WDS and IC4. The latter is in agreement with our determination.

3.2 Comparison with published ephemerides

The $(O - C)$ (Observed minus Computed) residuals of the measurements for the 34 systems with a known orbit of Table 1 are displayed in Table 2 in Cols. 5 and 6 for the separation ρ and position angle θ, respectively. Except for ADS 16270, for which we used the recent orbit of Zirm (2007), all the orbital elements used for computing the ephemerides were retrieved from OC6. The corresponding bibliographic references are indicated in Col. 2 as they appear in OC6. The ρ values in Col. 4 are the relevant observed separations, extracted 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 MCA 55Aac and ADS 14783, we also give the residuals obtained with our new orbits described in Sect. 5, for comparison.

As previously mentioned, for the objects for which we could not determine the quadrant, we reduced our θ measurement to the quadrant of the previous observation as reported in IC4. This procedure led to residuals spuriously close to 180° for ADS 1411 and 16173 AB when comparing with the orbits of Heintz (1997) and Söderhjelm (1999), respectively, since those authors had adopted the other quadrant convention. To avoid this problem, we have thus used their quadrant convention for computing the residuals reported in Table 2. This is indicated with the superscript ^{Q} in Col. 6.

As shown in Fig. 3, 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 48 residuals of Table 2 (after rejecting 2 outliers) are $\langle \Delta\rho_{O-C} \rangle = -0.''004 \pm 0.''07$ and $\langle \Delta\theta_{O-C} \rangle = -0.°4 \pm 1.°4$. The small values obtained for those offsets provide another validation of our calibration made in Nov. 2005 with a grating mask (see Paper III), which appears in good agreement with the measurements made by the other observers.

Let us examine now the cases of the binaries with the largest residuals, i.e. those who are located outside of the circle plotted in Fig. 3 whose radius corresponds to $\Delta\rho_{O-C} \approx 0.''14$ and $\Delta\theta_{O-C} \approx 3°$, i.e. about twice the standard deviations obtained with the residuals of Table 2. There are seven binaries in this category: WRH 28 (the large residuals put it outside the graph), ADS 1860, 11077, 14238, 14783, 15971 and MCA 55Aac.

WRH 28: The orbit proposed by Olevic & Cvetkovic (2005) gives ephemerides $\rho = 0.''16$, $\theta = 207°$ whereas our measurement is $\rho = 0.''07$ and $\theta = 302°$, which is in full disagreement (see Table 2). One could argue that this angular separation is below the diffraction limit of the Zeiss telescope in R, i.e. $\lambda/D \approx 0.''13$ (where λ is the central wavelength of the filter and D is the diameter of the telescope). In fact, this limit is not a rigid boundary and measurements of binaries can be obtained below this limit in favourable conditions (see Sect. 4). Although we cannot eliminate the possibility of an artefact, the auto-correlation central peak of our observation of WRH 28 is clearly elongated and the subtraction of the unresolved pattern leads to a well separated object. In fact the orbit of Olevic & Cvetkovic (2005) is very doubtful since it is based on a handful of measurements only, with a last measurement done in 1988 when $\rho \approx 0.''1$. Their orbit leads to a total system mass of 13 $M_\odot$ which is in disagreement with the astrophysical parameters of the stars. Indeed the spectral type is A7m and the absolute magnitude derived from Hipparcos parallax is $M_V = 0.31$ which implies a luminosity class of II-III and a mass estimated for each component at about 3 $M_\odot$. The total mass would then be 6 $M_\odot$, which is half that obtained by Olevic & Cvetkovic (2005).

STF 262 Aa-B, ADS 1860: Independent measurements of this pair made by one of us (RWA) with the Cambridge 8-inch refractor (Argyle, private communication) agree very closely with PISCO, which indicates that the large residuals are real. The recent orbit computed by Heintz (1996) no longer represents the last measurements. Unfortunately the available observations only cover a rather small arc of the orbit, with a small curvature, and it will be at least a few decades before it is possible to improve the orbit significantly.

AC 15 AB, ADS 11077: The recent orbit of Söderhjelm (1999) leads to a large residual in θ, but here also many other speckle observations are needed to allow the revision of this orbit.

MCA 55Aac, ADS 12540: The preliminary orbit of Hartkopf (1999) does not represent our observation, which suggests a very different apparent orbit. We propose a new (although still preliminary) solution in Sect. 5.

BU 64 AB, ADS 14238: Heintz' (1995) orbit begins to lead to large residuals in separation but more speckle observations are needed to permit a valuable revision.

H I 48, ADS 14783: The recent orbit of Söderhjelm (1999) does not represent our observation which is the first since the recent periastron passage. In particular the observed separation is much smaller than expected. We propose a new orbit in Sect. 5.

STF 2909, ADS 15971: It is a well-observed object with 1179 observations extending over nearly 230 yr. Independent observations with the Cambridge 8-inch refractor by RWA in 2005 (Argyle 2006) confirm the PISCO large resid-

Table 2 Residuals of the measurements of Table 1 with published orbits. In Col. 6, ^{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.)
102	Scardia (1980)	2005.897	0.800	−0.02	2.7
”	”	2005.935	0.822	0.00	2.1
102	Heintz (1997)	2005.897	0.800	−0.03	1.7
”	”	2005.935	0.822	−0.01	1.1
434	Ling (2005a)	2005.900	0.310	0.05	−0.9
”	”	2005.900	0.315	0.06	−0.6
WRH 28	Olevic (2005c)	2005.886	0.066	−0.09	95.1
755	Docobo (1990b)	2005.886	0.968	−0.03	−0.4
1097	Scardia (2001d)	2005.900	0.578	0.05	−0.3
1411	Baize (1986d)	2005.900	0.499	−0.01	−1.7
”	Heintz (1997)	2005.900	0.499	−0.11	-0.8^{Q}
1860Aa-B	Heintz (1996b)	2005.900	2.779	0.19	0.2
2616	Scardia (2002a)	2005.900	0.712	0.00	0.0
9744	Docobo (2006b)	2005.536	0.154	0.02	−2.1
”	”	2005.538	0.154	0.02	0.4
9756	Heintz (1975b)	2005.536	0.925	0.08	−0.3
9757	Hartkopf (1989)	2005.536	0.716	−0.02	0.3
9769	Scardia (2003a)	2005.505	0.675	−0.03	1.1
”	”	2005.506	0.662	−0.05	1.0
9969	Hopmann (1964b)	2005.596	4.065	−0.02	0.4
10075	Söderhjelm (1999)	2005.536	2.142	0.03	−0.5
10087	Heintz (1993b)	2005.536	1.426	−0.02	0.1
10279	Scardia (2002d)	2005.604	1.094	−0.07	−0.6
10345	Heintz (1981b)	2005.604	2.342	0.05	1.7
10828	Docobo (1990a)	2005.662	0.526	0.05	−2.2
11077AB	Söderhjelm (1999)	2005.708	0.851	−0.01	4.4
12033	Heintz (2001)	2005.793	0.540	0.04	1.4
MCA 55Aac	Hartkopf (1999b)	2005.820	0.382	0.10	3.2
”	This paper	”	”	0.01	−0.9
KUI 93	Docobo (2000a)	2005.820	0.191	0.01	-1.0^{Q}
”	Docobo (2005a)	2005.820	0.191	0.01	-1.0^{Q}
12880	Scardia (1983a)	2005.774	2.646	0.00	−0.9
13723	Heintz (1976)	2005.774	0.405	−0.05	−2.5
14238	Heintz (1995)	2005.883	0.643	0.13	−1.5
14773	Hartkopf (1996a)	2005.919	0.240	−0.01	−0.7
14783	Söderhjelm (1999)	2005.886	0.176	−0.26	−3.2
”	”	2005.886	0.174	−0.26	−4.4
”	This paper	2005.886	0.176	−0.03	0.4
”	”	2005.886	0.174	−0.03	−0.8
15971	Heintz (1984c)	2005.899	1.912	−0.18	−1.5
”	Olevic (2004a)	2005.899	1.912	−0.20	−3.5
15992	Cvetkovic (2005)	2005.883	0.505	0.01	−2.4
16157	Docobo (1997c)	2005.935	0.760	0.03	−1.5
16173AB	Söderhjelm (1999)	2005.951	0.203	0.02	-2.0^{Q}
16270AB	Zirm (2007)	2005.897	1.913	−0.05	0.4
16365	Baize (1981b)	2005.899	0.660	−0.12	0.3
”	”	2005.900	0.663	−0.12	−1.2
17149	Starikova (1977b)	2005.900	2.149	0.08	0.3

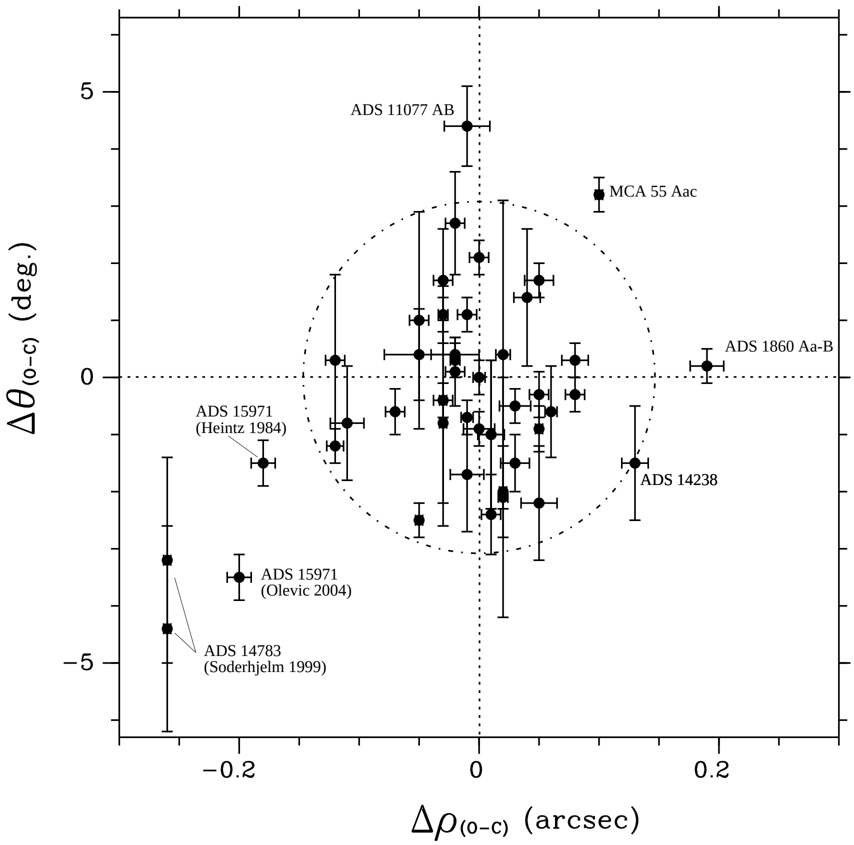

Fig. 3 Residuals from published orbits. The dashed circle has a radius of about twice the standard deviation of the residuals.

uals. Surprisingly, the old orbit published by Heintz (1984, with $P = 760$ yr) gives smaller angular residuals than that of Olevic & Cvetkovic (2004). Nevertheless, Olevic's orbit fits the bulk of the observations noticeably better than Heintz'. Actually, this system is triple with an astrometric third component of period 25 yr that must affect the distance and position angle of the long-period system. This effect was considered in Heintz' (1984) paper whereas it is not clear that Olevic has taken it into account. However, there seems to be a systematic offset of the data from Heintz' orbit which persists over several revolutions of the closest pair.

In conclusion, our analysis of the cases with the largest residuals showed that ADS 14783 and MCA 55Aac were good candidates for orbit revision, whereas the number of new observations is still insufficient for the other discrepant objects of Fig. 3.

4 New processing of old observations of close binaries

As mentioned in Sect. 2, we have improved the our data processing software to enable and facilitate the measurements of very close binaries. We have thus re-processed with our new method all the observations of the close binaries (with $\rho < 0''\!.25$) made in Merate since the installation of PISCO in 2004 (Papers I, II and III). The corresponding 27 new measurements concerning 21 objects are displayed in Table 3, with the same format as Table 1. In this table, we have only reported the cases for which the subtraction of the background improved significantly the quality of the previous measurements. The new processing has led to seven new positive detections, which are indicated in the notes column. In the other cases, the new measurements have smaller errors than the old ones, and are in good agreement with them. The mean differences are close to zero: $\langle \rho_{\rm new} - \rho_{\rm old} \rangle = -0''\!.010 \pm 0''\!.019$ and $\langle \theta_{\rm new} - \theta_{\rm old} \rangle = +0^\circ\!.5 \pm 2^\circ\!.3$. The rather large scatter obtained for θ is explained by the small value of the angular separation ρ of those objects, which leads to a larger uncertainty in θ.

The histogram of the ρ measurements of Table 3 (Fig. 4) clearly shows the gain in resolution obtained with the new processing. Some new measurements are even located below the diffraction limit ($\lambda/D = 0''\!.13$ in R). As already noted when discussing the case of WRH 28 in Sect. 3.2, this limit is not a rigid boundary and measurements of binaries can be obtained below the diffraction limit in favourable atmospheric conditions, with an appropriate data processing. Note also that skilled visual observers sometimes obtain micrometric measurements of binaries below this limit too.

The $O - C$ residuals of those new measurements are reported in Table 4 and displayed in Fig. 5. The average values are $\langle \Delta\rho_{O-C} \rangle = -0''\!.01 \pm 0''\!.03$ and $\langle \Delta\theta_{O-C} \rangle = -0^\circ\!.3 \pm 6^\circ\!.0$, which shows that our measurements do not

Table 3 New measurements of the closest binaries (with $\rho < 0\farcs25$) observed with PISCO between January 2004 and June 2005.

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	ρ (arcsec)	σ_ρ (arcsec)	θ (deg.)	σ_θ (deg.)	Orb.	Notes
02157+2503	COU 79	–	2004.972	V	10	0.152	0.006	263.9	1.2	1	
02537+3820	BU 524AB	2200	2004.101	V	10	0.189	0.003	341.6	1.0	1	
04239+0928	HU 304	3182	2004.082	V	10	0.219	0.004	9.6	1.0	1	
”	”	”	2004.095	V	10	0.208	0.004	7.0	1.0	1	
05373+6642	MLR 314	–	2005.109	R	10	0.197	0.004	251.7	1.0	1	
05386+3030	BU 1240AB	4229	2004.095	V	10	0.187	0.003	337.4	1.0	1	
”	”	”	2005.103	R	10	0.217	0.003	335.2	1.6	1	
06024+0939	A 2715AB	4617	2005.133	V	10	0.164	0.005	20.5	1.4	1	
06041+2316	KUI 23AB	–	2004.095	V	10	0.232	0.007	201.6	1.0	1	
”	”	”	2004.208	V	10	0.182	0.006	195.2	1.7	1	
”	”	”	2005.103	V	10	0.163	0.003	212.2	1.0	1	
06384+2859	MCA 27	–	2004.095	V	10	0.205	0.005	293.0	1.1	1	
”	”	”	2004.205	V	10	0.172	0.011	294.4	2.4	1	New detection
07351+3058	STT 175AB	6185	2004.211	V	10	0.110	0.004	142.1	5.2	1	New detection
”	”	”	2005.136	V	10	0.085	0.003	146.0	1.0	1	New detection
07573+0108	STT 185	6483	2004.260	V	10	0.124	0.005	353.3	2.7	1	New detection
08468+0625	SP 1AB	6993	2004.208	V	10	0.195	0.004	258.5	2.7	1	New detection
09036+4709	A 1585	7158	2004.205	V	10	0.137	0.003	309.7	1.2	1	
14323+2641	A 570	9301	2004.380	V	10	0.189	0.005	282.9	1.3	1	New detection
17304-0104	STF2173	10598	2004.673	V	10	0.212	0.003	189.5	1.0	1	
20251+5936	A 730	13850	2004.717	V	10	0.147	0.012	292.3	1.8	1	
21135+1559	HU 767	14761	2004.857	R	10	0.223	0.005	156.3	1.0	1	
21501+1717	COU 14	–	2004.952	V	10	0.139	0.003	312.9	1.0	1	New detection
22300+0426	STF2912	15988	2004.952	V	10	0.225	0.004	297.5	1.0	1	
22330+6955	STF2924AB	16057	2004.950	V	10	0.124	0.003	158.6	1.2	1	
23078+6338	HU 994	16530	2004.950	V	10	0.193	0.007	316.1	1.0	1	
23411+4613	MLR 4	–	2004.955	R	10	0.149	0.005	282.9	1.6	1	

have any systematic deviation from the published orbits. The large standard deviation obtained in θ is explained by the small angular separation of those pairs and the age of the orbits. We will now discuss the cases of the stars that appear as outliers with large residuals in Fig. 5, namely ADS 6185 and 6483.

ADS 6185: The last measurements made by other observers are in agreement with ours and are also diverging from the ephemerides of Hartkopf's (1989) orbit. Unfortunately, we cannot re-observe this pair since it is now too close to be resolved with our 102-cm telescope. The orbit is very inclined, almost edge-on to the plane of the sky. As a consequence the companion will approach the primary star to within $0\farcs05$, which will make it resolvable only with big telescopes or long baseline interferometers. More observations are required in the next few years to revise the orbit.

ADS 6483: Our measurement seem to indicate that Hartkopf's (2001) orbit no longer represents the actual motion of the companion. Indeed the ephemerides give a larger angular separation of $0\farcs27$ that would have been easily measured with our instrumentation. It is a pity that speckle observations are lacking between 1997 and 2004, which corresponded to a critical part of the orbit straddling the periastron. The absence of such observations prevents us from revising the orbit of this pair and new observations are clearly needed to define the motion of this object.

5 New orbits of ADS 684, MCA 55Aac and ADS 14783

In this section we present the new orbits we have computed for ADS 684, MCA 55Aac and ADS 14783, for which our measurements lead to large residuals and for which the revision was justified by the significant number of observations made since the last orbit computation.

For this revision, we used our measurements with PISCO and all the 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 5. In this table, Ω is the position angle of the ascending node, measured in the plane of the sky from north through east and ω is the longitude of the periastron in the

Table 4 Residuals of the new measurements of Table 3. In Col. 6, ^{Q} indicates discrepant quadrants between our measurements and the published orbits.

ADS/name	Orbit	Epoch	ρ(O) (arcsec)	$\Delta\rho$(O-C) (arcsec)	$\Delta\theta$(O-C) (deg.)
COU 79	Hartkopf (1996a)	2004.972	0.152	0.002	1.6
2200	Docobo (2001c)	2004.101	0.189	−0.015	0.1
3182	Hartkopf (2000b)	2004.082	0.219	0.000	0.7
”	”	2004.095	0.208	−0.012	−1.9
MLR 314	Mante (2001b)	2005.109	0.197	0.037	1.5
4229	Romero (2006)	2004.095	0.187	−0.017	+0.5
”	”	2005.103	0.217	0.011	−0.1
4617	Fekel (2002)	2005.133	0.164	−0.008	−7.0
KUI 23AB	Heintz (1986b)	2004.095	0.232	0.024	0.2
”	”	2004.208	0.182	−0.021	−7.6
”	”	2005.103	0.163	0.003	−4.8
MCA 27	Hartkopf (2000c)	2004.095	0.205	−0.009	4.8
”	”	2004.205	0.172	−0.041	6.5
6185	Hartkopf (1989)	2004.211	0.110	0.028	7.5
”	”	2005.136	0.085	0.013	13.9
6483	Hartkopf (2001b)	2004.260	0.124	−0.101	−14.3
6993	Hartkopf (1996a)	2004.208	0.195	−0.016	1.4
7158	Barnaby (2000)	2004.205	0.137	−0.005	3.6
9301	Heintz (1991)	2004.380	0.189	−0.013	9.4^Q
10598	Heintz (1994a)	2004.673	0.212	−0.007	0.6
13850	Heintz (1986b)	2004.717	0.147	−0.039	−8.4
14761	Hartkopf (1996a)	2004.857	0.223	0.006	−4.7
COU 14	Hartkopf (1989)	2004.952	0.139	−0.013	−4.4
15988	Söderhjelm (1999)	2004.952	0.225	−0.014	-2.0^Q
16057	Söderhjelm (1999)	2004.950	0.124	−0.001	−9.8
16530	Docobo (1991e)	2004.950	0.193	−0.059	4.0
MLR 4	Hartkopf (1996a)	2004.955	0.149	−0.008	0.2

Table 5 New orbital elements for ADS 684, MCA 55Aac and ADS 14783.

Name	Ω (2000)	ω (deg)	i (deg)	e	T (yr)	P (yr)	n (deg/yr)	a (arcsec)	A (arcsec)	B (arcsec)	F (arcsec)	G (arcsec)
ADS 684	64.9	11.4	31.9	0.621	1914.52	201.0	1.791	0.531	0.14012	0.50917	−0.44470	0.09241
	±5.7	±5.4	±2.6	±0.014	±0.29	±9.0	±0.080	±0.033				
MCA 55Aac	170.4	39.4	154.9	0.256	1997.995	213.859	1.68335	0.536	-0.35701	0.37285	0.39800	0.31308
ADS 14783	62.2	45	83.7	0.81	2003.5	81.71	4.406	0.690	0.17923	0.45514	−0.27554	−0.40821
	±1.5	±18	±2.3	±0.07	±2.4	±0.70	±0.038	±0.030				

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). Note that only the preliminary elements are given for MCA 55Aac, since convergence could not be obtained for Hellerich's minimisation, which also explains the absence of error bars in this case.

The corresponding $(O-C)$ residuals, restricted to the last observations for reasons of space, are given in Tables 6, 7 and 8 for ADS 684, MCA 55Aac and ADS 14783, 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. 6 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. The big cross indicates the location of the primary component, and the straight dashed 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 2007–2016 are presented in Table 9, with the date in Besselian years in Col. 1, the angular separation ρ in Cols. 2, 4 and 6 the position angle θ in Cols. 3, 5 and 7.

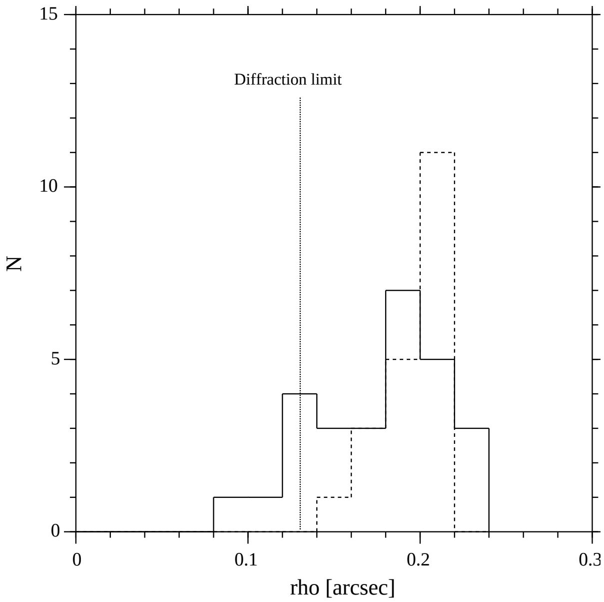

Fig. 4 Distribution of the new ρ measurements (solid line) compared to the previously published values (dashed line) of the closest binaries observed from Januar 2004 to June 2005 in Merate. The diffraction limit λ/D for the R filter and the 102-cm Zeiss telescope is indicated for comparison.

Table 6 ADS 684: $O-C$ residuals of our new orbit (for the measurements made after 1995). The symbol $^{\rm P}$ indicates a PISCO measurement.

Epoch	$\Delta\rho$ (O-C) (arcsec)	$\Delta\theta$ (O-C) (deg.)
1995.818	0.022	0.2
1995.921	0.029	−1.1
1997.689	−0.062	2.8
1997.810	0.138	−1.7
1998.882	−0.034	−1.1
2000.803	0.012	0.0
2001.791	−0.039	0.9
2002.270	0.070	1.3
2002.925	−0.011	−1.5
2003.720	0.048	0.1
2003.831	−0.002	−0.7
2003.952	0.008	−0.9
2003.970	−0.002	1.5
2005.034	0.047^P	-1.6^P
2006.025	0.031^P	-0.5^P

Table 7 MCA 55Aac: $O-C$ residuals of our new orbit (for the measurements made after 1990). The symbol $^{\rm P}$ indicates a PISCO measurement.

Epoch	$\Delta\rho$ (O-C) (arcsec)	$\Delta\theta$ (O-C) (deg.)
1990.743	−0.001	−0.5
1991.250	−0.010	−0.2
1991.610	−0.089	1.3
1991.896	−0.001	0.5
1992.311	0.003	−0.1
1994.708	0.002	0.5
1995.314	−0.004	0.1
1995.557	0.008	−1.0
1995.762	−0.001	1.4
1996.423	−0.003	0.7
1996.500	0.003	1.0
1996.698	−0.002	0.6
1998.657	0.003	0.5
2000.761	0.049	1.6
2000.785	−0.020	−5.3
2002.473	−0.078	−5.5
2005.820^P	0.006^P	-0.9^P

Table 8 ADS 14783: $O-C$ residuals of our new orbit (for the measurements made after 1987). The symbol $^{\rm P}$ indicates a PISCO measurement.

Epoch	$\Delta\rho$ (O-C) (arcsec)	$\Delta\theta$ (O-C) (deg.)
1987.471	0.171	−3.1
1987.590	0.044	−2.8
1988.590	0.057	−2.4
1988.730	0.071	4.6
1988.884	0.017	2.2
1989.616	0.000	2.3
1989.633	0.111	5.1
1989.633	0.131	4.9
1990.553	0.022	−1.6
1990.553	−0.018	0.6
1990.562	0.123	−3.2
1990.680	0.007	−8.3
1991.250	−0.009	−0.4
1991.562	0.007	−0.1
1991.710	−0.031	3.0
1992.692	−0.015	0.4
2005.886	-0.030^P	0.2^P
2005.886	-0.032^P	-1.0^P

5.1 WDS 00504+5038 – BU 232 AB – ADS 684

This binary was discovered by Burnham with his famous 6-inch refractor on 1874 October 16 (Burnham 1875), but the first measurements were made only two years later by the Italian Baron E. Dembowski. The last published orbits computed by P. Muller (1951), P. Baize (1964) and G.A. Starikova (1985) now leave systematic residuals both in separation and in position angle. The most recent observation used by G.A. Starikova was made in 1980.904.

Our new orbit is based on 104 measurements, and includes 31 observations made after 1980.904, mostly from speckle interferometry. The orbital elements reported in Table 5 that we have obtained lead to residuals with standard deviations of $0\farcs067$ and $2\fdg00$ for ρ and θ, respectively. The spectral type of F5 leads to a dynamic parallax computed by Baize-Romani's method (Couteau 1978) of $0\farcs0114$ which is in good agreement with the measured parallax. Indeed, the Hipparcos parallax is $\pi = 0\farcs01306 \pm 0\farcs00203$. The corresponding total mass of the system would be 1.7 $M_\odot$, with an uncertainty of 51%, which is compatible with the

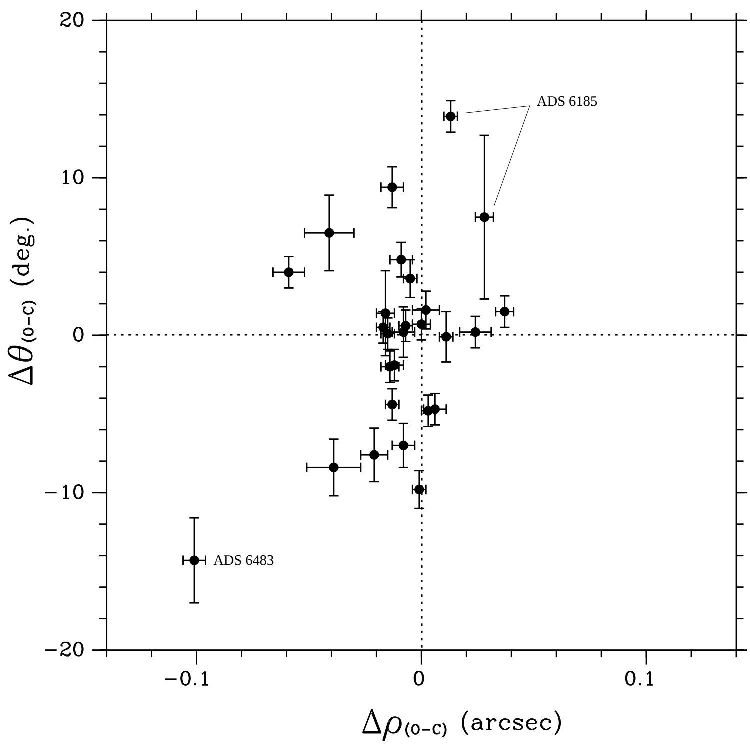

Fig. 5 Residuals from published orbits for the new measurements of Table 3.

Table 9 New ephemeris of ADS 684, MCA 55Aac and ADS 14783.

Epoch	ADS 684 ρ (arcsec)	ADS 684 θ (deg)	MCA 55Aac ρ (arcsec)	MCA 55Aac θ (deg)	ADS 14783 ρ (arcsec)	ADS 14783 θ (deg)
2007.0	0.855	251.0	0.376	107.1	0.313	239.2
2008.0	0.856	251.4	0.376	104.1	0.393	240.3
2009.0	0.856	251.9	0.377	101.1	0.462	241.1
2010.0	0.856	252.3	0.378	98.2	0.522	241.7
2011.0	0.857	252.8	0.379	95.2	0.574	242.1
2012.0	0.857	253.2	0.381	92.3	0.621	242.5
2013.0	0.857	253.7	0.382	89.4	0.663	242.8
2014.0	0.856	254.2	0.385	86.5	0.700	243.1
2015.0	0.856	254.6	0.387	83.6	0.734	243.4
2016.0	0.856	255.1	0.390	80.8	0.764	243.6

spectral type. This parallax leads to a semi-major axis of 40.7±3.6 AU.

5.2 WDS 19307+2758 – MCA 55Aac – ADS 12540

MCA 55 Aac (in the Beta 1 Cyg–Albireo multiple system) was discovered in 1976 with the 2.1-m telescope of Kitt Peak National Observatory (McAlister & Hendry, 1982). Since its discovery, this pair has been regularly observed, mostly with speckle techniques. Thinking that it could also be a spectroscopic binary, Hendry (1981) examined the 39 spectra of Beta 1 taken between 1898 and 1980 but she did not find any evidence of an orbital motion in those spectra. The first orbit of MCA 55 Aac was published by Hartkopf in 1999, but it is not compatible with the recent separation measured with PISCO. We have thus computed a new orbit with all the measurements available and found the orbital elements given in Table 5. The mean rms residuals of the 46 measurements that we have used are 0.″02 and 2° for ρ and θ respectively. Because of the small angular coverage of the orbit, our orbit has to be considered as preliminary only, with a quality grading of 4–5 (preliminary indeterminate).

The Hipparcos parallax is 0.″00846 ±0.″00058, and the spectral type is K3 III + B0 V according to ten Brummelaar et al. (2000) or K3 II (Bidelman 1958) + B9 V (Bahng 1958) or even K5 II + B (Bonneau & Foy 1980). The semi major-axis would then be 63.4 AU with the Hipparcos parallax. The systemic mass derived from our orbital elements is 5.6 $M_\odot$, hence the total mass of Beta 1 Cyg is slightly underestimated. Our determination favours the old spectral classification of Bidelman and Bahng. Alternatively, the total systemic mass derived from Hartkopf's (1999) orbital elements is 35 $M_\odot$ which is larger than all the values found in the literature, even for the most massive combination K3 III + B0 V of 22 $M_\odot$ proposed by Staizys & Kuriliene (1981). Our orbit looks thus more satisfactory, but more observations are required to monitor a larger part of the orbit, to improve our knowledge of the orbital elements and refine the systemic mass determination.

5.3 WDS 21137+6424 – H 1 48 – ADS 14783

Although the observations of ADS 14783 are rather numerous and cover about two revolutions, the orbit of this system

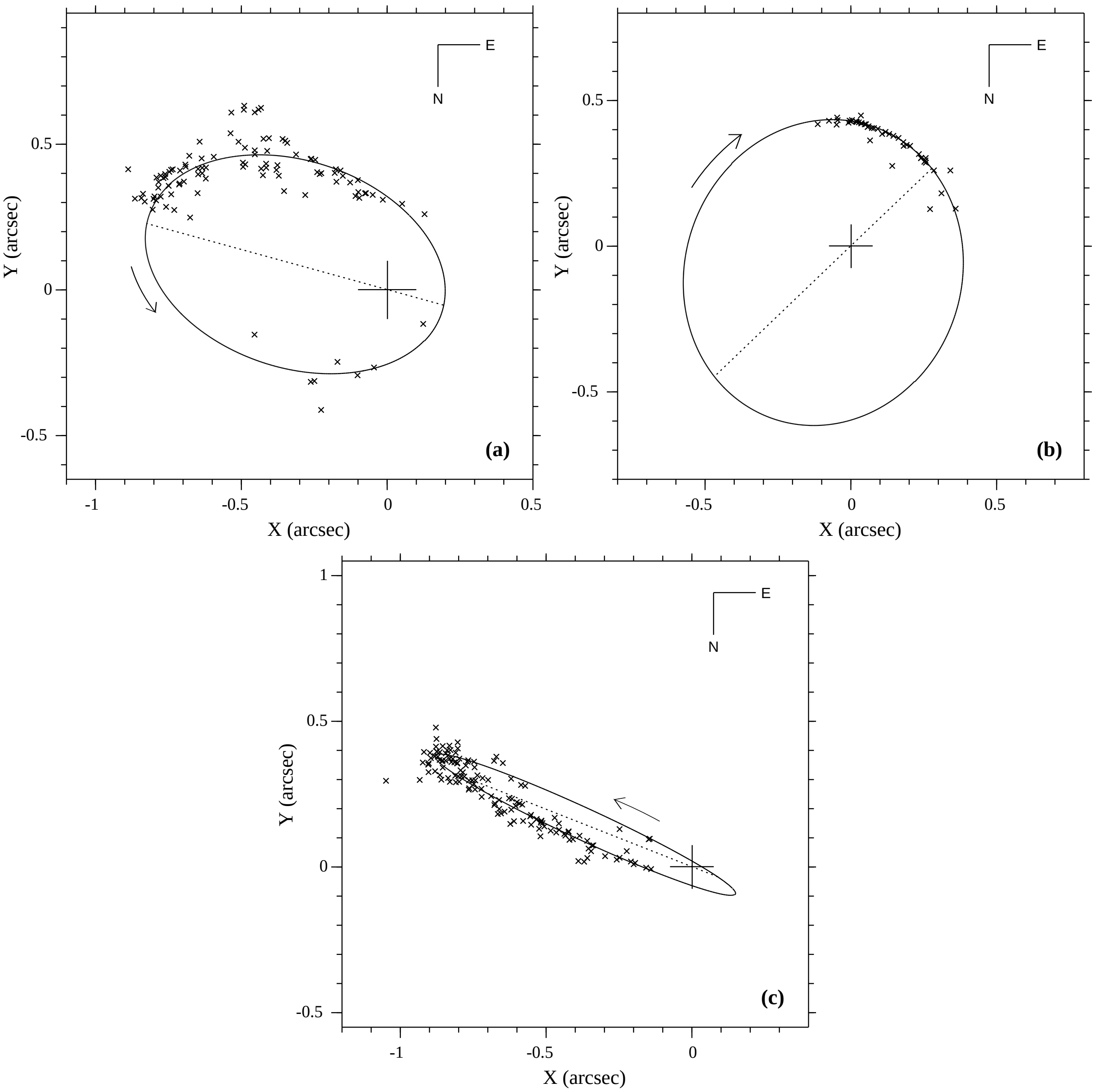

Fig. 6 New orbits of ADS 684 (*a*), MCA 55Aac (*b*) and ADS 14783 (*c*).

is still badly known because the orbital plane has a large inclination i, which makes the observations close to periastron very difficult, with angular separations smaller than $0\farcs1$. The last positive detections that led to measurements before our observations were done visually by Muller in 1992 (Muller 1997) and at the same epoch with speckle interferometry by Miura (1993).

Our two measurements made in 2005 (the first made after the last periastron passage) and the three most recent measurements obtained by other observers are in disagreement with Söderhjelm's (1999) orbit. In particular the observed separations are much smaller than expected. The old orbit by Baize (1984), which was computed with the observations made before 1980, is in better agreement with the measurements made in the period 1980–2007 than that of Söderhjelm (1999).

We have thus computed a new orbit with our measurements and obtained the orbital elements given in Table 5. Our orbit well accounts for the 145 measurements available both in ρ and θ with standard deviations of the residuals of $0\farcs009$ and $2\fdg0$ respectively, and leads to a reasonable value for the sum of the masses. Indeed with the parallax of $0\farcs02416 \pm 0\farcs00048$ obtained by Hipparcos, the systemic mass is 3.5 $\mathrm{M}_\odot$ with an uncertainty of 14.4%. This is in good agreement with the expected masses for two stars of spectral type G2 IV, which is attributed to both stars in the literature. Note the small value of the uncertainty that we have found, mainly because of the good accuracy of the

Hipparcos parallax for this nearby system (at 41 pc from the sun). The semi-major axis would be 28.6±1.4 AU.

6 Conclusion

In the second semester of 2005, we performed 130 observations of 120 objects with PISCO in Merate. When adding those made since 2004, the total reaches 686 observations, which is larger than the number of binary observations (≈ 400) made with PISCO on the 2-m 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.

We have found a candidate for a new triple system, ADS 11077, and invite other observers to perform independent observations to confirm this finding.

The new data processing procedure that we have developed for processing the auto-correlations was found very efficient to measure very close binaries. Used for reprocessing the old observations of the closest binaries made with PISCO in Merate, this method significantly improved the quality of the previously published measurements. We managed to obtain seven new measurements from observations that had not been previously resolved, and reached in some cases separations smaller than the diffraction limit of the Zeiss 102-cm telescope.

Our observations with PISCO have allowed us to improve the orbits of ADS 684, 14783 and MCA 55Aac. This revision was justified by the large residuals found for our measurements and by the significant number of new observations made since the last computation. The values found for the system total masses are consistent with the spectral type of the stars and the dynamic parallaxes are in good agreement with the parallaxes measured by Hipparcos.

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