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Speckle observations with PISCO in Merate (Italy): XIV. Astrometric measurements of visual binaries in 2013, and new orbits for ADS 1097, 5871, 7203, 7775, 9378, 9578 and 11186

M. Scardia¹, J.-L. Prieur^{2,3}, L. Pansecchi¹, R.W. Argyle⁴, A. Zanutta¹, and E. Aristidi⁵

¹ INAF – Osservatorio Astronomico di Brera, Via E. Bianchi 46, 23807 Merate, Italy

² Université de Toulouse – UPS-OMP – IRAP, Toulouse, France

³ CNRS – IRAP, 14 avenue Edouard Belin, 31400 Toulouse, France

⁴ Institute of Astronomy, Madingley Road, Cambridge, CB3 0HA, United Kingdom

⁵ Université de Nice-Sophia Antipolis – Laboratoire Lagrange – CNRS–OCA, Parc Valrose 06108 Nice cedex 2, France

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We present relative astrometric measurements of visual binaries, made in 2013 with the speckle camera PISCO at the 102-cm Zeiss telescope of Brera Astronomical Observatory, in Merate. Our observing list contains orbital couples as well as binaries whose motion is still uncertain. We obtained 134 new measurements of 129 visual binary stars, with angular separations in the range $0''.23$ — $5''$, and an average accuracy of $0''.01$. The mean error on the position angles is $0^\circ.5$. Most of the position angles were 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 new revised orbits for ADS 1097, 5871, 7203, 7775, 9378, 9578 and 11186, partly derived from PISCO observations. The corresponding estimated values for the masses of those systems are compatible with the spectral types.

1 Introduction

This paper presents the results of speckle observations of visual binary stars made in Merate (Italy) in 2013 with the Pupil Interferometry Speckle camera and COronagraph (PISCO) on the 102-cm Zeiss telescope of *INAF – Osservatorio Astronomico di Brera* (OAB, Brera Astronomical Observatory). It is the fourteenth of a series whose purpose is to contribute to the determination of binary orbits (Scardia et al. 2005, 2006, 2007, 2008a, Prieur et al. 2008, Scardia et al. 2009, Prieur et al. 2009, Scardia et al. 2010, Prieur et al. 2010, Scardia et al. 2011, Prieur et al. 2012, Scardia et al. 2013, and Prieur et al. 2014 herein: Papers I to XIII). The focal instrument PISCO was developed at *Observatoire Midi-Pyrénées* (France) and first used at *Pic du Midi* from 1993 to 1998. It was moved to Merate in 2003 and installed on the INAF Zeiss telescope that has been dedicated to binary star observations since that epoch.

In Sect. 2, we briefly describe our observations. In Sect. 3, we present and discuss the astrometric measurements. We also compare those measurements with the ephemerides computed with the published orbital elements, when available. Finally in Sect. 4 we present

the new revised orbits that we have computed for ADS 1097, 5871, 7203, 7775, 9378, 9578 and 11186 and discuss the estimated values for the masses of those systems.

2 Observations

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

2.1 Observing list

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

The distribution of the angular separations measured in this paper is displayed in Fig. 1a and shows a maximum for $\rho \approx 0''.6$. The largest separation of $4''.98$

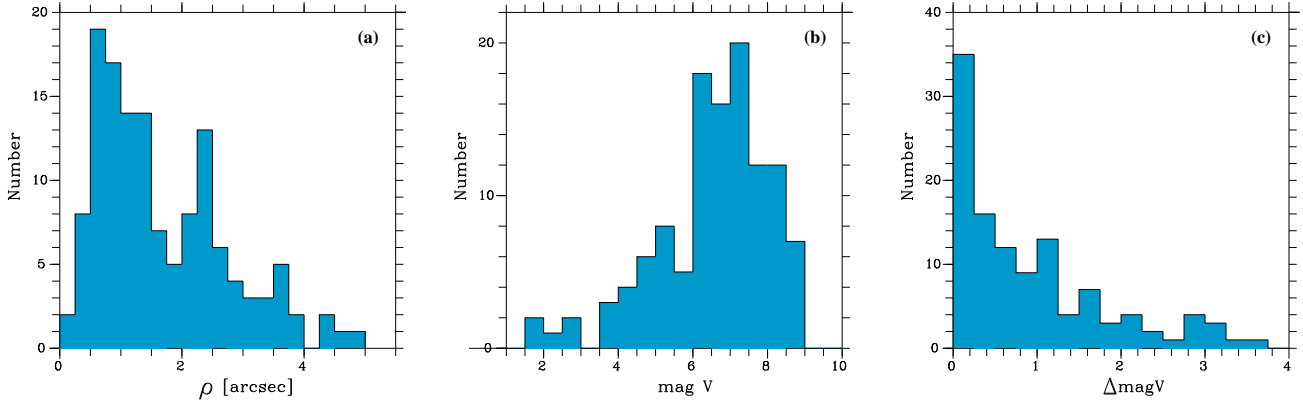


Fig. 1 Distribution of the angular separations of the 134 measurements of Table 1 (a), the total visual magnitudes of the corresponding binaries (b) and the differences of magnitude between their two components (c).

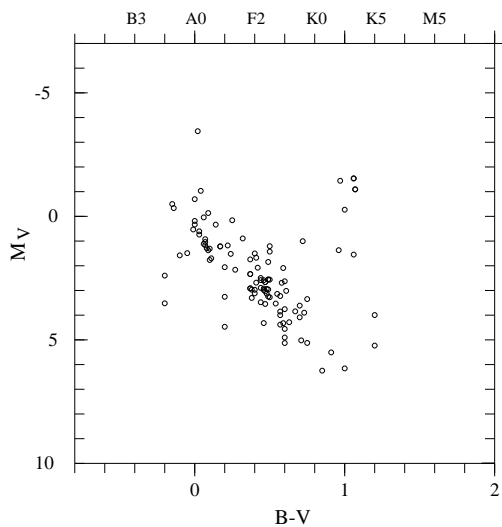


Fig. 2 HR diagram of the binaries measured in Table 1, for which Hipparcos parallaxes were obtained with a relative error smaller than 50% (i.e., 109 objects).

was obtained for ADS 6175 and the smallest separation was measured for ADS 11468, with $\rho = 0''.228$. Let us recall that the diffraction limit is $\rho_d = \lambda/D \approx 0''.13$ for the Zeiss telescope (aperture $D = 1.02$ m) and the R filter ($\lambda = 650$ nm).

The distribution of the apparent magnitudes m_V and of the difference of magnitudes Δm_V between the two components are plotted in Figs. 1b and 1c, respectively. The telescope aperture and detector sensitivity led to a limiting magnitude of about $m_V = 9$ (Fig. 1b) and a maximum Δm_V for speckle measurements of about 3.8 (Fig. 1c).

Using the Hipparcos parallaxes, we were able to construct the HR diagram of those binaries, which is displayed in Fig. 2. We only plotted the objects for which the relative uncertainty on the parallax was smaller than 50%. This concerned 109 objects only.

3 Astrometric measurements

The 134 astrometric measurements obtained with the observations made in 2013 are displayed in Table 1. They concern 129 visual binaries. For each object, we report its WDS name (Washington Double Star Catalog, Mason et al. 2014, hereafter WDS catalog) in Col. 1, the official double star designation in Col. 2 (sequence is “discoverer-number”), and the ADS number in Col. 3 (Aitken, 1932) when available. For each observation, we then give the epoch in Besselian years (Col. 4), the filter (Col. 5), the focal length of the eyepiece used for magnifying the image (Col. 6), the angular separation ρ (Col. 7) with its error (Col. 8) in arcseconds, and the position angle θ (Col. 9) with its error (Col. 10) in degrees. In Col. 11, we report some notes and some information about the secondary peaks of the auto-correlation files (e.g. diffuse, faint or elongated) or about the power spectrum (NF: no fringes). We reported “Triple?” for ADS 9630, since we noticed the presence of a faint pattern in the secondary peaks of the autocorrelation that may be due to the presence of an unknown third component. For the systems with a known orbit, the $(O - C)$ (Observed minus Computed) residuals of the ρ and θ measurements are displayed in Cols. 13 and 14, respectively. The corresponding authors are given in Col. 12, using the bibliographic style of the “Sixth Catalog of Orbits of Visual Binary Stars” (Hartkopf & Mason, 2014, hereafter OC6). When not explicitly specified, the measurements refer to the AB components of those systems. In Col. 14, the symbol Q indicates that there was a quadrant inconsistency between our measures and the positions derived from the orbital elements published for this object.

The characteristics of the R and RL filters used for obtaining those measurements are given in Table 2 of Paper XIII. Some objects were observed without any filter because they were too faint. This is indicated with

Table 1 Table of speckle measurements and O-C residuals with published orbits (begin.)

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	ρ (")	σ_ρ (")	θ ($^\circ$)	σ_θ ($^\circ$)	Notes	Orbit	$\Delta\rho(\text{O-C})$ (")	$\Delta\theta(\text{O-C})$ ($^\circ$)
05247+6323	STF677	3956	2013.174	R	20	1.116	0.017	116.4*	0.6		Hrt2008	-0.02	1.0
05308+0557	STF728	4115	2013.174	R	20	1.277	0.008	44.9*	0.4		USN1999b	-0.02	0.3
05312+0318	STF729	4123	2013.174	R	20	1.922	0.010	27.2*	0.4				
07057+5245	STF1009	5746	2013.174	R	32	4.306	0.022	147.7*	0.3				
07128+2713	STF1037	5871	2013.174	R	20	0.978	0.011	307.2*	0.5		Sta1981a	0.00	0.6
"	"	"	"	"	"	"	"	"	"		This paper	0.04	0.3
07346+3153	STF1110	6175	2013.174	R	32	4.983	0.025	55.4*	0.3		Hei1988a	0.06	-0.5
08095+3213	STF1187	6623	2013.289	R	32	3.127	0.016	21.1*	0.3		Ole2001	0.18	0.4
08482+0235	BU335	7003	2013.174	R	32	2.485	0.021	264.9*	0.5	NF			
08500+3935	STF1279	7019	2013.297	R	32	1.253	0.016	87.0*	0.3				
08505+2308	AG157	7035	2013.297	W	32	2.272	0.016	75.2*	0.4	Elongated			
08561+4341	STF3120	7092	2013.175	R	32	1.343	0.016	0.2*	0.6				
08571+1045	A2968	7102	2013.297	W	20	1.164	0.011	132.8*	0.4	Elongated			
09006+4147	KUI37	-	2013.289	R	10	0.553	0.005	215.0*	0.4	Elongated	Sod1999	-0.01	-0.8
09104+6708	STF1306	7203	2013.287	R	20	4.339	0.022	348.5*	0.3	NF	Sca1985c	0.09	-0.4
"	"	"	"	"	"	"	"	"	"		This paper	0.06	-0.1
09127+1632	STF1322	7236	2013.289	R	32	1.801	0.016	53.0*	0.4				
09136+4659	STF1318	7243	2013.289	R	32	2.626	0.017	228.3*	0.4				
09188+3648	STF1334	7292	2013.287	R	20	2.641	0.013	223.2*	0.3				
09210+3811	STF1338	7307	2013.314	R	20	1.116	0.008	305.9*	0.4		Sca2002b	-0.02	0.2
09239+2754	STT201	7344	2013.314	R	32	1.220	0.017	204.8*	0.4				
09245+1808	A2477	7341	2013.314	R	20	0.452	0.008	3.4*	1.2	Elongated	FMR2014a	0.02	0.9
09285+0903	STF1356	7390	2013.289	R	20	0.780	0.008	107.0*	0.3		Mut2010b	-0.01	-0.2
09300+4216	A1985	7398	2013.289	R	32	1.577	0.016	24.6	0.6				
09377+1153	HJ165	7461	2013.314	R	32	2.361	0.027	347.8*	0.4				
09414+3857	STF1374	7477	2013.289	R	32	2.793	0.016	308.9*	0.3		Lin2013a	-0.03	-1.2
09476+5057	HU630	7514	2013.314	R	32	2.244	0.024	72.6	0.4				
09513+6037	STF1381	7536	2013.289	R	32	0.798	0.022	186.2	0.3				
09521+5404	STT208	7545	2013.290	R	10	0.381	0.003	300.3	0.4		Hei1996c	-0.03	-1.0
09524+2659	STF1389	7551	2013.314	R	32	2.481	0.019	289.8*	0.3				
09572+4554	STF1394	7588	2013.314	R	32	4.593	0.025	249.2*	0.3				
10029+0742	STF1403	7617	2013.314	W	32	2.876	0.027	333.5*	0.3				
10163+1744	STT215	7704	2013.298	R	20	1.485	0.008	176.8*	0.3		Wrz1956c	-0.07	-0.4
10205+0626	STF1426	7730	2013.298	R	20	0.910	0.012	311.7*	0.3	Diffuse	Sca2008c	0.01	-0.6
"	"	"	"	"	"	"	"	"	"		Nov2006	-0.00	-0.5
10227+1521	STT216	7744	2013.298	R	32	2.266	0.027	232.2*	0.3		Sca2009c	0.06	0.0
10250+2437	STF1429	7758	2013.298	R	20	0.809	0.013	156.9*	0.3		Zul1981	0.06	-1.0
10350+0839	STF1450	7837	2013.298	R	32	2.108	0.017	155.8*	0.3				
10406+4209	STF1460	7878	2013.298	R	32	3.760	0.019	162.0*	0.3				
11037+6145	BU1077	8035	2013.287	V	10	0.698	0.003	0.1*	0.3		Sca2011a	0.01	-1.7
"	"	"	2013.366	R	10	0.682	0.007	359.8*	0.5	NF	Sca2011a	-0.01	-1.6
11050+3825	HO378	8047	2013.287	R	20	1.083	0.011	236.1*	1.0				
11136+5525	A1353	8092	2013.287	R	20	0.569	0.008	209.8*	0.7		Doc1999b	0.03	0.1
11137+2008	STF1517	8094	2013.287	R	20	0.657	0.008	316.1	0.4		FMR2011a	-0.02	-0.5
11154+2734	STF1521	8105	2013.314	R	32	3.650	0.018	96.3*	0.3				
11182+3132	STF1523	8119	2013.314	R	20	1.657	0.010	187.7*	0.3		Msn1995	-0.02	0.0
11190+1416	STF1527	8128	2013.287	R	10	0.300	0.006	223.8	0.3	Elongated	Tok2012b	-0.01	1.0
11239+1032	STF1536	8148	2013.314	R	20	2.070	0.014	97.8*	0.3	NF	Sta1980a	0.02	-0.1
11245+2037	STF1537	8149	2013.290	R	32	2.277	0.016	358.3*	0.7				
11332+4927	HU727	8210	2013.314	R	32	1.220	0.016	204.7*	1.0				
11363+2747	STF1555	8231	2013.287	R	20	0.719	0.008	148.8*	0.4		Doc2007i	0.04	-1.1
11371+4040	A1996	8241	2013.366	R	32	1.991	0.036	189.6	0.7				
11388+6421	STF1559	8249	2013.314	R	32	1.956	0.021	322.9*	0.4				
12417-0127	STF1670	8630	2013.448	RL	20	2.024	0.010	9.7*	0.4		Sca2007c	-0.00	-0.1
"	"	"	2013.459	R	20	2.021	0.010	9.6*	0.3		Sca2007c	-0.01	-0.2

Table 1 Table of speckle measurements and O-C residuals with published orbits (cont.)

WDS	Name	ADS	Epoch	Fil.	Eyep. (mm)	ρ (")	σ_ρ (")	θ ($^\circ$)	σ_θ ($^\circ$)	Notes	Orbit	$\Delta\rho(\text{O-C})$ (")	$\Delta\theta(\text{O-C})$ ($^\circ$)
13007+5622	BU1082	8739	2013.448	RL	20	0.918	0.015	111.4*	0.3		Sca2012c	-0.06	1.2
"	"	"	"	"	"	"	"	"	"		Doc2014	-0.00	0.5
"	"	"	"	"	"	"	"	"	"		Dru2014	0.00	-0.8
"	"	"	2013.459	RL	20	0.940	0.011	111.5*	0.3		Sca2012c	-0.03	1.3
"	"	"	"	"	"	"	"	"	"		Doc2014	0.02	0.6
"	"	"	"	"	"	"	"	"	"		Dru2014	0.03	-0.7
13048+7302	BU799	8772	2013.459	R	20	1.387	0.008	265.1*	0.3				
13100+1732	STF1728	8804	2013.459	R	10	0.346	0.004	11.8	0.5	Elongated	Pal2005b	-0.00	0.0 ^Q
13120+3205	STT261	8814	2013.462	R	20	2.613	0.013	338.3*	0.3		Kis2012	0.04	-0.2
13207+0257	STF1734	8864	2013.462	R	20	1.112	0.008	174.0*	0.3				
14153+0308	STF1819	9182	2013.448	R	20	0.877	0.008	171.6*	0.6		Sca2012b	-0.01	0.6
14203+4830	STF1834	9229	2013.459	R	20	1.641	0.008	102.6*	0.3		USN2000c	0.07	-1.0
14220+5107	A148	9238	2013.459	R	20	0.553	0.008	191.6	1.4	NF			
14336+3535	STF1858	9312	2013.497	R	32	3.046	0.016	37.9*	0.3				
14380+5135	STF1863	9329	2013.459	R	20	0.648	0.008	59.2*	0.3		Zir2013a	-0.00	-1.3
14407+3117	STF1867	9340	2013.459	R	20	0.703	0.008	353.7*	0.5		Zir2013a	0.03	-0.4
14450+2704	STF1877	9372	2013.459	R	20	2.855	0.014	343.7*	0.3				
14455+4223	STT285	9378	2013.448	R	20	0.464	0.019	85.4*	1.1		Cou1973b	-0.03	1.6
"	"	"	"	"	"	"	"	"	"		This paper	-0.02	1.5
"	"	"	2013.462	R	20	0.498	0.008	83.6*	0.9		Cou1973b	0.00	-0.2
"	"	"	"	"	"	"	"	"	"		This paper	0.02	-0.2
14489+0557	STF1883	9392	2013.459	R	20	0.983	0.008	278.2	0.4		Sta1982b	-0.08	0.2
15183+2650	STF1932	9578	2013.448	R	20	1.620	0.008	264.2*	0.3		Sod1999	-0.01	0.2
"	"	"	"	"	"	"	"	"	"		This paper	-0.00	-0.4
15257+2638	STF1941	9630	2013.448	R	32	1.367	0.025	211.1	1.1	Triple?			
15277+0606	STF1944	9647	2013.448	W	20	0.657	0.008	295.2*	0.3				
15348+1032	STF1954	9701	2013.459	R	32	3.985	0.027	172.0*	0.3		Kiy2010	-0.08	0.3
15360+3948	STT298	9716	2013.459	R	20	1.160	0.008	182.4*	0.4		Cou1989c	-0.02	0.2
16289+1825	STF2052	10075	2013.672	R	32	2.307	0.016	119.2*	0.3		Sca1984d	-0.03	-0.7
16518+2840	STF2107	10235	2013.678	R	20	1.416	0.014	103.2*	0.3		Sca2003c	0.02	-1.1
16564+6502	STF2118	10279	2013.675	R	20	1.003	0.008	65.1*	0.3		Sca2002d	-0.15	-1.7
17020+0827	STF2114	10312	2013.675	R	20	1.310	0.009	195.3*	0.3				
17053+5428	STF2130	10345	2013.672	R	20	2.444	0.012	4.1	0.3		Pru2012	-0.03	-0.1
17055+1033	BU357	10336	2013.675	RL	32	1.389	0.016	305.7*	0.8	Faint			
17246+1536	STF2160	10528	2013.683	R	32	3.740	0.024	66.3*	0.5	NF			
17266+3546	STF2168	10558	2013.684	R	32	2.312	0.016	201.9*	0.6				
17304-0104	STF2173	10598	2013.684	R	20	0.792	0.013	147.9*	0.3		Hei1994a	-0.02	-0.9
17317+1111	AG354	10612	2013.722	R	32	2.522	0.016	51.0*	0.3				
17350+6153	BU962	10660	2013.722	R	20	0.625	0.029	300.5*	1.0		Sod1999	-0.01	-2.1
17457+1743	STF2205	10769	2013.730	R	32	0.931	0.016	7.3*	0.9		Cve2008a	-0.08	0.5
17471+1742	STF2215	10795	2013.678	R	10	0.470	0.005	251.4*	0.6	Elongated	Cve2006e	0.01	2.5
17479+1449	STF2222	10803	2013.733	R	32	2.263	0.041	62.5*	0.5				
17506+0714	STT337	10828	2013.678	R	20	0.556	0.016	164.4	0.7		Doc1990a	0.04	0.6
17512+4454	STF2242	10849	2013.678	R	32	3.252	0.016	145.4*	0.4				
17518+2814	STF2239	10851	2013.678	R	32	2.444	0.016	317.0*	0.5				
17520+1520	STT338	10850	2013.678	R	20	0.807	0.008	163.6*	0.4		Pru2012	-0.02	-0.8
17567+4837	STF2258	10924	2013.730	R	32	2.075	0.024	220.9*	1.1				
17571+0004	STF2244	10912	2013.681	R	12	0.681	0.011	99.1*	0.6	Elongated	Hei1997	0.15	-2.1
18014+6557	STF2284	11016	2013.675	R	32	3.547	0.025	191.1*	0.3				
18101+1629	STF2289	11123	2013.675	R	20	1.206	0.008	218.6*	0.5		Hop1964b	-0.03	2.7
18146+0011	STF2294	11186	2013.675	R	20	1.335	0.008	92.5*	0.3		Luy1934a	0.17	-0.3
"	"	"	"	"	"	"	"	"	"		This paper	0.02	-0.9
18239+5848	STF2323	11336	2013.722	R	32	3.656	0.018	348.1*	0.3		Nov2006e	-0.09	-0.2
18250+2724	STF2315	11334	2013.681	R	12	0.648	0.006	118.1*	0.3		WSI2004b	0.03	0.6
18278+2442	STF2320	11373	2013.733	R	32	1.038	0.025	358.4*	0.6				
18320+0647	STT354	11432	2013.684	R	20	0.562	0.008	214.9*	1.4		Zir2013a	-0.02	1.9

Table 1 Table of speckle measurements and O-C residuals with published orbits (cont.)

WDS	Name	ADS	Epoch	Fil.	Eyep.	ρ	σ_ρ	θ	σ_θ	Notes	Orbit	$\Delta\rho(\text{O-C})$	$\Delta\theta(\text{O-C})$
					(mm)	($''$)	($''$)	($^\circ$)	($^\circ$)			($''$)	($^\circ$)
18339+5221	A1377	11468	2013.675	R	10	0.228	0.005	129.7*	0.5		Mut2010e	-0.02	0.5
"	"	"	2013.681	R	12	0.228	0.009	131.3*	1.3		Mut2010e	-0.02	2.1
18355+2336	STT359	11479	2013.675	R	10	0.725	0.005	4.4*	0.4	Elongated	Sca2009a	-0.02	-0.0
18359+1659	STT358	11483	2013.684	R	20	1.623	0.008	148.6*	0.3		Hei1995	0.11	1.4
18443+3940	STF2382	11635	2013.676	R	20	2.260	0.012	346.3*	0.3		Nov2006e	-0.03	-0.1
"	"	"	"	"	"	"	"	"	"		WSI2004b	-0.10	-0.1
18443+3940	STF2383CD	11635	2013.676	R	20	2.352	0.012	76.5*	0.3		Doc1984b	-0.03	-0.1
18508+1059	STF2404	11750	2013.678	R	32	3.492	0.035	180.9*	0.4	Diffuse			
18540+3723	BU137	11811	2013.678	R	32	1.509	0.024	163.6*	0.4				
18545+2037	STF2415	11816	2013.678	R	32	1.874	0.043	287.2*	0.7				
18570+3254	BU648	11871	2013.730	R	20	1.224	0.008	245.7*	0.3		Doc2008f	0.02	-0.2
18571+2606	STF2422	11869	2013.678	W	20	0.724	0.017	69.5*	1.1				
18575+5814	STF2438	11897	2013.678	R	20	0.850	0.008	357.9*	0.3		Hrt2001a	0.02	0.6
18581+4711	AG366	11899	2013.796	R	32	1.397	0.016	187.2*	0.3				
19062+3026	STF2454	12040	2013.722	R	32	1.253	0.016	288.1*	0.4		Baz1976	-0.07	-0.3
19159+2727	STT371	12239	2013.796	R	20	0.862	0.008	160.2*	0.3				
19160+1610	STT368	12236	2013.796	R	20	1.129	0.010	217.8*	0.8				
19177+2302	BU248	12287	2013.733	R	20	1.666	0.015	127.3*	0.3	NF			
19266+2719	STF2525	12447	2013.733	R	32	2.103	0.016	288.2*	0.3		Hei1984b	-0.04	-1.4
19334+6203	STF2553	12626	2013.730	R	32	0.975	0.025	130.0*	1.3				
19346+1808	STT375	12623	2013.730	R	20	0.605	0.012	188.3*	1.3				
19365+4101	STT378	12687	2013.730	R	32	1.354	0.017	284.2*	0.3				
19450+4508	STF2579	12880	2013.722	R	20	2.684	0.013	217.2*	0.3		Sca2012c	-0.03	-0.7
19464+3344	STF2576FG	12889	2013.722	R	32	2.915	0.021	157.1*	0.3				
19487+3519	STT387	12972	2013.722	R	20	0.488	0.016	113.8*	0.6		WSI2006b	-0.02	-1.0
19540+1518	STF2596	13082	2013.722	R	32	2.003	0.016	298.3*	0.3				
20014+1045	STF2613	13256	2013.834	R	32	3.500	0.017	354.3*	0.3		Hop1973b	-0.65	2.3
20020+2456	STT395	13277	2013.722	R	20	0.774	0.008	125.1*	0.4		Zir2013a	-0.08	-1.1
20102+4357	STT400	13461	2013.834	R	20	0.627	0.008	330.4	1.5		Hei1997	-0.01	-0.6
20203+3924	STF2668AB-C	13728	2013.796	R	32	3.334	0.017	278.5*	0.3				
20229+4259	HO128	13786	2013.834	R	20	1.335	0.008	358.5*	0.3				
20396+4035	STT410	14126	2013.834	R	20	0.856	0.009	3.6	0.5		Hrt2011a	-0.01	-0.3
21018+3916	STF2746	14558	2013.722	R	20	1.205	0.014	322.6*	0.3				
21103+4359	STF2773	14711	2013.730	R	32	3.190	0.016	112.4*	0.3				
21111+4530	BRT1146	-	2013.730	W	32	2.639	0.019	345.2*	0.3	Elongated			

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

W (for “white” light) in the filter column (Col. 5 of Table 1).

3.1 Quadrant determination

As for the other papers of this series, position measurements were obtained by an interactive processing of the auto-correlation files computed in real time during the observations. This processing led to a series of measurements with different background estimates and simulated noise, from which we derived the mean values and the standard deviation of those multiple measurements (see Paper III for more details). The final measures and their errors are displayed in Table 1. The average error values of the measurements reported in this table are $\langle\sigma_\rho\rangle = 0''.014 \pm 0''.007$ and $\langle\sigma_\theta\rangle = 0^\circ.5 \pm 1^\circ.3$.

As our astrometric measurements were obtained from the *symmetric* auto-correlation files, the θ values first presented a 180° ambiguity. To resolve this ambiguity and determine the quadrant containing the companion, Aristidi et al. (1997) have proposed a method that can be considered as a restricted triple correlation (RTC hereafter). The quadrants of the measurements indicated in Table 1 were mostly derived from the RTC files that were computed in real time during the observations. However, for the couples with the largest separations, a straightforward determination was done

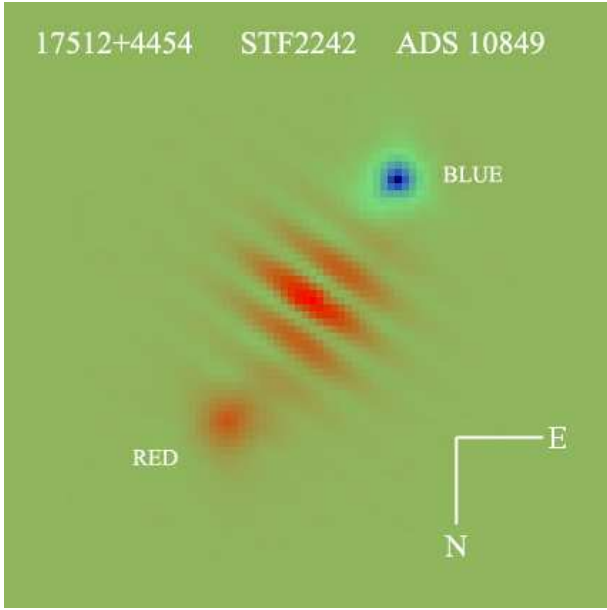


Fig. 3 Quadrant determination of ADS 10849 with a RTC (Restricted Triple Correlation) method. The red and blue spots correspond to the primary and secondary components, respectively. They are labelled RED and BLUE, respectively, for the convenience of the readers of the printed paper (black and white version).

when the companions could be directly spotted on the long integration files.

As a result, in Table 1, we are able to give the unambiguous (i.e. “absolute”) position angles of 119 out of 134 measurements, i.e. 89% of the total. They are marked with an asterisk in Col 9. When our quadrant determination procedure failed, the angular measurement was reduced to the quadrant reported in the WDS catalog, which is extracted from the Fourth Catalog of Interferometric Measurements of Binary Stars (Hartkopf et al. 2014, hereafter IC4).

Our “absolute” θ values are consistent with the values tabulated in WDS for all objects except for ADS 10849. For this object, $\Delta m_V = 0.1$, the RTC file clearly shows that our quadrant determination of Q=2 (South-East) is unquestionable (see Fig. 3). In IC4 there are 10 observations of this object, of which 3 were made by us, and the quadrant is always Q=4. However, for our 3 observations the quadrant could not be determined so that we adopted the quadrant of the already published observations.

A possible explanation for this discrepancy may be that we observed with a R filter, whereas most of the other observers used a V filter. A different spectral type of the two components could account for a quadrant inversion.

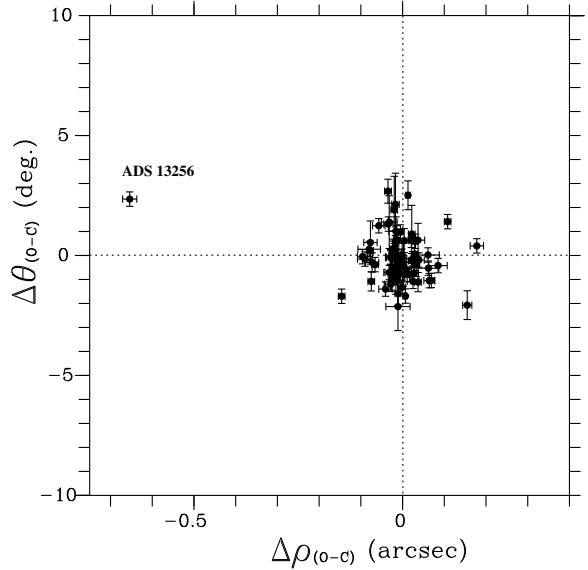


Fig. 4 Residuals of the measurements of Table 1 computed with the published orbits.

3.2 Comparison with published ephemerides

The ($O - C$) (Observed minus Computed) residuals of the measurements for the systems with a known orbit in Table 1 are displayed in Cols. 13 and 14 for the separation ρ and position angle θ , respectively. Those residuals were obtained with a selection of valid orbits found in the OC6 catalog. We did not always use the most recent orbits since sometimes older orbits led to equivalent or even smaller residuals. For ADS 5871, 7203, 9378, 9578 and 11186, we also reported the residuals obtained with our revised orbit presented in Sect. 4.

The residuals are plotted in Fig. 4. ADS 13256 which lies on the far left edge of this figure should be considered separately. It corresponds to the largest residual in Table 1 ($\Delta\rho = -0''.65$, $\Delta\theta = 2^\circ.3$) with Hopmann (1973)’s orbit. This orbit was computed long ago, with insufficient data. The arc of the monitored orbit was very short in 1973, and has not yet increased sufficiently to enable a valid orbit calculation. Furthermore, the motion seems rectilinear, and it is likely that the two components of ADS 13256 are not gravitationally linked.

When excluding ADS 13256, Fig. 4 shows that the residuals have a rather small scatter. Indeed, the mean values computed with the residuals of Table 1 are $\langle\Delta\rho_{O-C}\rangle = -0''.005 \pm 0''.051$ and $\langle\Delta\theta_{O-C}\rangle = -0^\circ.1 \pm 1^\circ.0$. The small values obtained for those offsets provide a good validation of our calibration (see Paper XII).

Table 2 New orbital elements of ADS 1097, 5871, 7203, 7775, 9378, 9578 and 11186.

ADS	Ω_{2000} ($^{\circ}$)	ω ($^{\circ}$)	i ($^{\circ}$)	e	T (yr)	P (yr)	n ($^{\circ}/\text{yr}$)	a ($''$)	A ($''$)	B ($''$)	F ($''$)	G ($''$)
1097	149.8	242.8	141.0	0.89	1942.93	291.05	1.237	0.430	0.02037	-0.35575	-0.40738	0.06036
5871	38.5 ± 2.1	259.5 ± 1.9	144.7 ± 1.3	0.933 ± 0.002	1920.34 ± 0.01	118.35 ± 0.46	3.042 ± 0.012	0.794 ± 0.020	-0.50988	0.40857	0.53747	0.57842
7203	102.1 ± 1.9	332.4 ± 1.9	145.4 ± 1.5	0.801 ± 0.017	1917.39 ± 0.12	970 ± 118	0.3712 ± 0.005	5.80 ± 0.14	-3.24016	4.56214	3.57364	3.51430
7775	121.2	219.9	47.3	0.984	1966.983	139.789	2.575	0.470	0.36167	-0.20251	0.05298	0.38455
9378	71.4 ± 6.0	171.0 ± 6.1	164.5 ± 1.6	0.5232 ± 0.002	2060.738 ± 0.099	88.933 ± 0.085	4.048 ± 0.004	0.327 ± 0.010	-0.05630	-0.32183	-0.31129	0.05079
9578	63.79 ± 0.21	51.26 ± 0.24	58.56 ± 0.13	0.6527 ± 0.0017	1941.484 ± 0.024	203.145 ± 1.3	1.7721 ± 0.011	1.21 ± 0.019	-0.10724	0.89677	-0.77119	-0.67231
11186	91.10	173.80	101.60	0.935	1890.086	344.837	1.04397	0.732	0.02986	-0.72728	-0.14478	-0.08185

4 Revised orbits of ADS 1097, 5871, 7203, 7775, 9378, 9578 and 11186

In this section we present the new revised orbits that we have computed for ADS 1097, 5871, 7203, 7775, 9378, 9578 and 11186. Those objects belong to our list of regularly monitored couples with PISCO. The revision of those orbits was justified by the appearance of a systematic trend in the residuals of our last measurements and/or the existence of substantial number of new measurements since the computation of the last known orbit.

We have followed the same method for revising the orbits of those seven objects. Using our last measurements with PISCO and the other available observations contained in the data base maintained by the United States Naval Observatory (USNO), we first computed the preliminary orbital elements with the analytical method of Kowalsky (1873). We then used them as initial values for the least-squares method of Hellerich (1925). When convergence was achieved, Hellerich's method led to an improvement of the orbital elements (with the exception of the major axis) and to an estimation of the corresponding errors. The final value of the major axis was then set to the value that minimized the residuals in separation of Hellerich's solution.

The final orbital elements are presented in Table 2. The errors reported in this table were obtained by Hellerich's least-squares method. For ADS 1097, 7775, and 11186, the errors could not be estimated since Hellerich's method did not converge. The format of the tables contained in this section is self-explanatory, but a detailed description of those formats can be found in Papers VI and VII.

The ($O-C$) residuals of the new orbits, restricted to the last observations for reasons of space, are given in Tables 3, 4, 5, 6, 7, 8, and 9, for ADS 1097, 5871, 7203,

7775, 9378, 9578 and 11186, respectively. The name of the observer is reported in the last column, using the US Naval Observatory convention.

The ephemerides for 2015–2025 are presented in Table 10. The apparent orbits are shown in Figs. 5 and 6 as solid lines. The observational data used for the calculation of the orbital elements are plotted as small crosses or, in the case of PISCO observations, as filled circles (that appear in red in the electronic version). The orientation of the graphs conforms to the convention adopted by the observers of visual binary stars. For each object, the location of the primary component is indicated with a big cross. The straight line going through this point is the line of apsides. An arrow shows the sense of rotation of the companion.

In Table 11, we present some physical parameters of those systems. The (total) visual magnitudes (Col. 3) and the spectral types (Col. 5) were extracted from the SIMBAD data base. The difference of magnitude between the components (Col. 4) was taken from the IC4. The dynamical parallaxes (Col. 6) were derived from our orbital elements using Baize & Romani (1946)'s method, with our revised formulae presented in Scardia et al. (2008b). In Col. 7, we report the Hipparcos parallaxes from ESA (1997) or the revised values from van Leeuwen (2007), as indicated in Col. 11. In Cols. 8, 9 and 10, we give the corresponding angular and linear sizes of the semi-major axis a and the total mass $\mathfrak{M}_{\text{total}}$, respectively, that were computed from our orbital elements and the Hipparcos parallaxes.

WDS 01213+1132 – BU 4 – ADS 1097 – HIP 6334

This couple was discovered by S.W. Burnham, on October 24th 1872 in Chicago (Burnham, 1873). Burnham was using an outstanding 6-inch Clark refractor that he installed in the backyard of his house. This couple was rather well measured after this discovery,

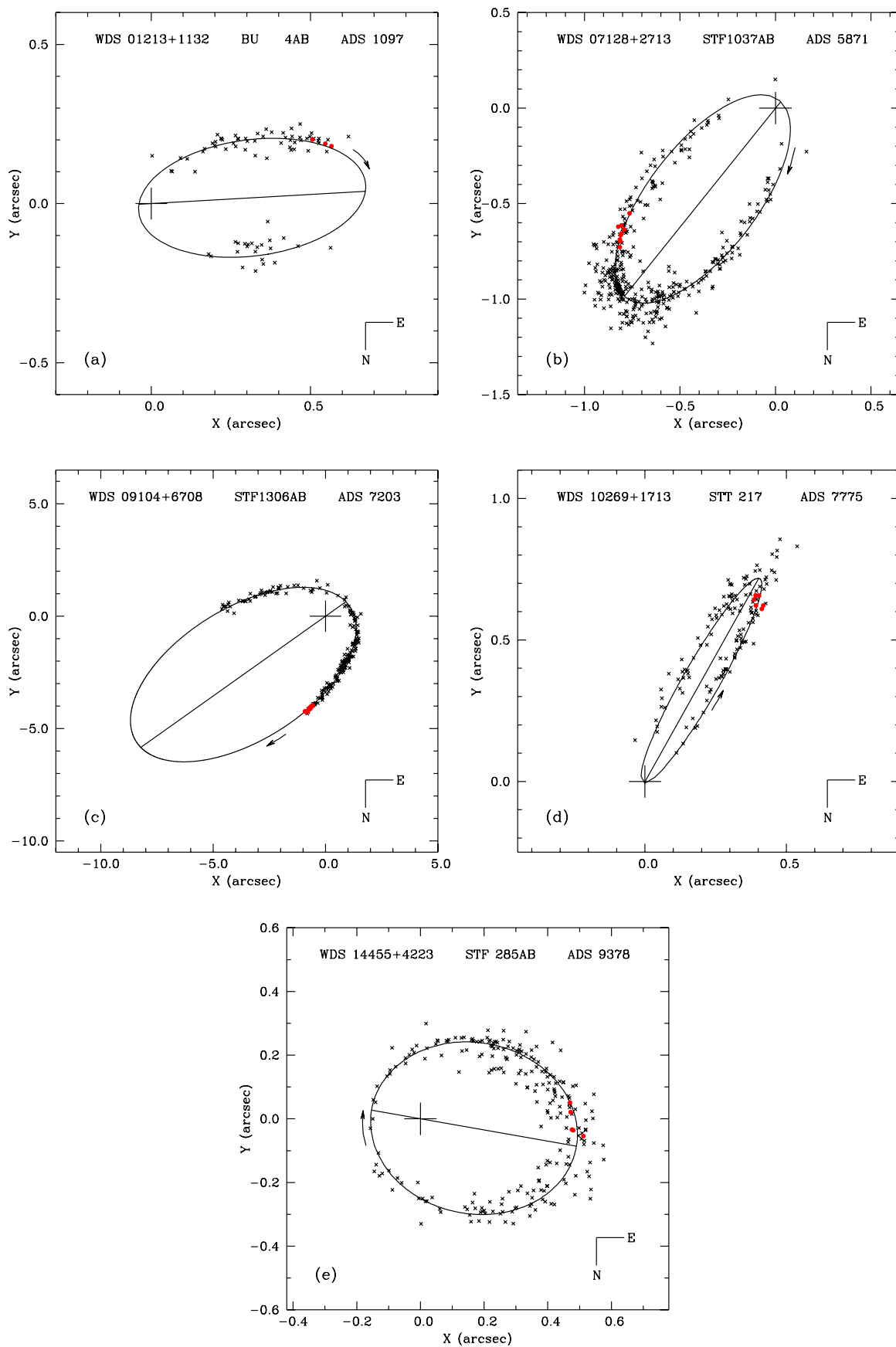


Fig. 5 New orbits of ADS 1097 (a), ADS 5871 (b), ADS 7203 (c), ADS 7775 (d), and ADS 9378 (e) The observations by PISCO are plotted as filled circles that appear in red in the electronic version of this paper.

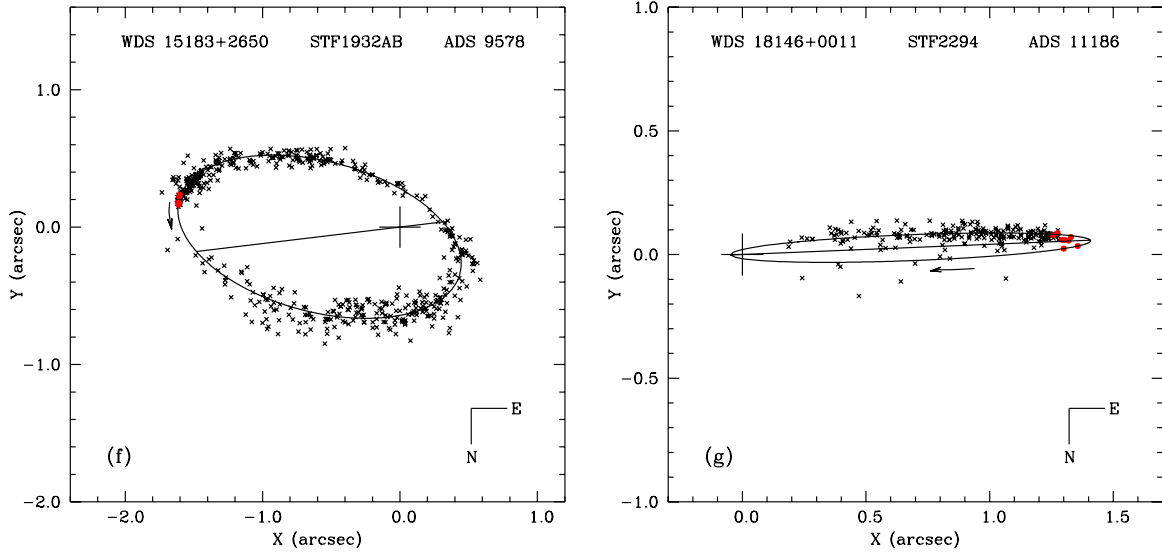


Fig. 6 New orbits of ADS 9578 (f) and ADS 11186 (g). The observations by PISCO are plotted as filled circles that appear in red in the electronic version of this paper.

Table 3 ADS 1097: O-C residuals of our new orbit (after 2001). The symbol ^P indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) ($''$)	$\Delta\theta$ (O-C) ($^\circ$)	Observer
2001.873	0.032	-4.2	Hor
2001.873	0.022	0.5	Hor
2005.900	0.020 ^P	-0.6 ^P	Sca
2007.964	0.029 ^P	-1.4 ^P	Sca
2007.995	0.089	-0.3	Gii
2008.885	-0.068	9.3	CTr
2008.888	0.022	1.0	Orl

but it was unfortunately not observed between 1924 and 1945, which was the epoch when the periastron passage occurred.

The last orbit of ADS 1097 that we computed in Scardia et al. (2001) needed some revision because the residuals of the last measurements were beginning to show a systematic trend. Using the 91 measurements made since its discovery, we obtained the orbital elements reported in Table 2, with mean residuals of $\langle\Delta\rho_{O-C}\rangle = 0''.042$ and $\langle\Delta\theta_{O-C}\rangle = 3^\circ.6$. The orbit is rather eccentric with a lack of observations close to the periastron (see Fig. 5a). The parallax computed by van Leeuwen leads to an excessive mass, whereas the ESA parallax gives an acceptable result and is in very good agreement with the dynamical parallax.

WDS 07128+2713 – STF 1037 – ADS 5871 – HIP 34860

This couple was discovered by F.G.W. Struve in Dorpat (now Tartu, Estonia) during the binary star survey he made in 1825–1827 with the famous 25-cm

Table 4 ADS 5871: O-C residuals of our new orbit (after 2009). The symbol ^P indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) ($''$)	$\Delta\theta$ (O-C) ($^\circ$)	Observer
2009.139	-0.026 ^P	-0.6 ^P	Sca
2009.153	-0.020	0.6	WSI
2009.201	-0.020	0.2	Ctt
2009.909	-0.019	0.8	FMR
2010.160	0.055	-0.7	StJ
2010.196	0.007 ^P	-1.7 ^P	Pru
2011.178	0.042	0.8	Thr
2012.156	0.028	0.7	FMR
2012.156	0.028	0.7	Bvd
2013.174	0.039 ^P	0.3 ^P	Sca
2014.196	-0.013 ^P	-0.6 ^P	Sca

Table 5 ADS 7203: O-C residuals of our new orbit (after 2009). The symbol ^P indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) ($''$)	$\Delta\theta$ (O-C) ($^\circ$)	Observer
2009.207	0.016 ^P	0.0 ^P	Sca
2009.359	-0.166	1.9	Ary
2010.196	0.113 ^P	-0.0 ^P	Pru
2011.310	-0.029	0.3	Mwl
2011.313	0.111	0.7	Mwl
2012.203	0.094 ^P	-0.4 ^P	Pru
2012.217	0.162	0.7	Mwl
2012.251	0.036	0.1	Dru
2012.284	0.059	-0.4	Dal
2013.287	0.056 ^P	-0.1 ^P	Sca
2014.196	0.016 ^P	-0.3 ^P	Sca

Table 10 New ephemerides of ADS 1097, 5871, 7203, 7775, 9378, 9578 and 11186.

Epoch	ADS 1097		ADS 5871		ADS 7203		ADS 7775		ADS 9378		ADS 9578		ADS 11186	
	ρ (")	θ (°)	ρ (")	θ (°)	ρ (")	θ (°)	ρ (")	θ (°)	ρ (")	θ (°)	ρ (")	θ (°)	ρ (")	θ (°)
2015.0	0.588	107.4	0.940	305.9	4.337	347.9	0.783	148.5	0.497	81.9	1.622	265.2	1.319	93.4
2016.0	0.591	107.1	0.920	305.3	4.369	347.6	0.787	148.6	0.498	80.5	1.621	265.6	1.323	93.4
2017.0	0.594	106.9	0.900	304.6	4.400	347.3	0.791	148.7	0.498	79.0	1.620	266.0	1.330	93.3
2018.0	0.597	106.7	0.879	303.9	4.432	346.9	0.795	148.8	0.497	77.6	1.619	266.4	1.333	93.3
2019.0	0.600	106.5	0.857	303.1	4.463	346.6	0.798	148.9	0.497	76.2	1.617	266.8	1.336	93.3
2020.0	0.602	106.2	0.834	302.3	4.494	346.3	0.802	149.0	0.495	74.7	1.615	267.2	1.339	93.2
2021.0	0.605	106.0	0.810	301.5	4.525	346.0	0.805	149.1	0.494	73.3	1.613	267.6	1.342	93.2
2022.0	0.608	105.8	0.785	300.6	4.556	345.7	0.807	149.2	0.492	71.8	1.610	268.0	1.345	93.2
2023.0	0.610	105.6	0.759	299.7	4.587	345.4	0.810	149.3	0.490	70.3	1.608	268.3	1.348	93.2
2024.0	0.613	105.3	0.732	298.6	4.617	345.1	0.812	149.4	0.487	68.8	1.604	268.7	1.351	93.1
2025.0	0.615	105.1	0.704	297.5	4.648	344.8	0.814	149.5	0.484	67.3	1.601	269.1	1.353	93.1

Table 6 ADS 7775: O-C residuals of our new orbit (after 2007). The symbol ^P indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) (")	$\Delta\theta$ (O-C) (°)	Observer
2007.261	-0.006 ^P	-1.7 ^P	Pru
2008.251	-0.009	1.3	Gii
2008.284	0.006	0.7	Gii
2008.284	0.023	0.8	Gii
2008.314	-0.000 ^P	-1.6 ^P	Pru
2009.301	0.025	1.9	Ant
2009.330	-0.006 ^P	1.3 ^P	Sca
2010.188	-0.004	1.0	Los
2012.380	-0.006 ^P	1.1 ^P	Sca

Table 8 ADS 9578: O-C residuals of our new orbit (after 2009). The symbol ^P indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) (")	$\Delta\theta$ (O-C) (°)	Observer
2009.487	0.000	1.7	Nvl
2009.649	-0.010	-0.3	WSI
2010.388	0.014	-0.4	Los
2010.435	-0.131	0.5	WSI
2010.456	0.009	0.5	Ant
2010.538	-0.007 ^P	0.3 ^P	Pru
2011.444	-0.012	0.1	Bvd
2012.457	0.003 ^P	-0.5 ^P	Sca
2013.307	-0.017	-0.3	RAO
2013.448	-0.003 ^P	-0.4 ^P	Sca

Table 7 ADS 9378: O-C residuals of our new orbit (after 2005). The symbol ^P indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) (")	$\Delta\theta$ (O-C) (°)	Observer
2005.404	0.000 ^P	-0.0 ^P	Sca
2006.320	-0.007	-0.5	WSI
2007.312	0.007	0.3	Hrt
2007.380	-0.011	2.6	Alz
2007.381	-0.005	-1.3	Gii
2007.542	-0.010 ^P	-0.4 ^P	Sca
2010.223	0.052	1.3	Los
2011.485	-0.015 ^P	-1.1 ^P	Sca
2013.448	-0.015 ^P	1.5 ^P	Sca
2013.462	0.019 ^P	-0.2 ^P	Sca

Table 9 ADS 11186: O-C residuals of our new orbit (after 2008). The symbol ^P indicates PISCO measurements.

Epoch	$\Delta\rho$ (O-C) (")	$\Delta\theta$ (O-C) (°)	Observer
2008.665	0.021 ^P	-1.0 ^P	Pru
2009.266	0.029	-0.4	Tok
2009.440	0.001	-0.9	FMR
2009.608	-0.004	-2.4	WSI
2009.686	0.003 ^P	-0.2 ^P	Sca
2010.500	0.050	-2.0	Los
2011.660	0.023 ^P	-0.8 ^P	Sca
2012.635	0.034 ^P	-0.7 ^P	Pru
2013.675	0.022 ^P	-0.9 ^P	Sca

refractor built by Fraunhofer. The first measurement was made in March 1827 (Struve, 1837).

Both the orbit of Scardia (1983, last obs. 1980.09) and the most recent one computed by Söderhjelm (1999) begin to show systematic residuals both in ρ and θ . Consequently we took advantage of the 130 new measurements obtained since 1980 and revised our first orbit. The new orbital elements are displayed in Table 2 and the apparent orbit is plotted in Fig. 5b. They

lead to mean residuals of 0".073 and 1°.6, for ρ and θ , respectively. The uncertainties of the orbital elements are very small and this orbit is close to being definitive. Indeed, the measurements are numerous (426 observations have been made since its discovery in 1827) and nearly two orbital revolutions have been well monitored by the observations. However the orbit is very eccentric ($e = 0.933$) and the last periastron passage could not

Table 11 Physical parameters (π_{dyn} , a and $\mathfrak{M}_{\text{total}}$) derived from the new orbital elements.

ADS	HIP	m_V	Δm_V	Spectral type	π_{dyn} (mas)	π_{HIP} (mas)	a (")	(AU)	$\mathfrak{M}_{\text{total}}$ (M_{\odot})	Source of π_{HIP}
1097	6334	6.90	1.3	F0V	6.2	6.16	0.430	70	4.0	ESA (1997)
"	"	"	"	"	"	± 1.41	"	$\pm 16^{(1)}$	$\pm 2.8^{(1)}$	
"	"	"	"	"	"	4.84	"	89	8.3	van Leeuwen (2007)
"	"	"	"	"	"	± 0.64	"	$\pm 12^{(1)}$	$\pm 3.3^{(1)}$	
5871	34860	6.44	0.0	F8V	25.2	22.65	0.794	35	3.1	ESA (1997)
"	"	"	"	"	"	± 2.03	± 0.020	± 3	± 0.9	
"	"	"	"	"	"	23.54	"	34	2.7	van Leeuwen (2007)
"	"	"	"	"	"	± 0.55	"	± 1	± 0.3	
7203	45038	4.80	4.0	F7V+K2V	47.3	48.87	5.80	119	1.8	ESA (1997)
"	"	"	"	"	"	± 0.62	± 0.14	± 3	± 0.5	
"	"	"	"	"	"	49.07	"	118	1.8	van Leeuwen (2007)
"	"	"	"	"	"	± 0.37	"	± 3	± 0.5	
7775	51145	7.43	0.5	F8V	12.8	11.67	0.47	40	3.3	ESA (1997)
"	"	"	"	"	"	± 2.70	"	$\pm 9^{(1)}$	$\pm 2.3^{(1)}$	
"	"	"	"	"	"	11.80	"	40	3.2	van Leeuwen (2007)
"	"	"	"	"	"	± 1.44	"	$\pm 5^{(1)}$	$\pm 1.2^{(1)}$	
9378	72153	7.33	0.1	F5V	11.9	11.81	0.327	28	2.7	ESA (1997)
"	"	"	"	"	"	± 1.26	± 0.010	± 3	± 0.9	
"	"	"	"	"	"	11.93	"	27	2.6	van Leeuwen (2007)
"	"	"	"	"	"	± 0.77	"	± 2	± 0.6	
9578	74893	6.58	0.1	G0V	27.1	26.10	1.21	46	2.4	ESA (1997)
"	"	"	"	"	"	± 1.27	± 0.019	± 2	± 0.4	
"	"	"	"	"	"	27.79	"	44	2.0	van Leeuwen (2007)
"	"	"	"	"	"	± 0.81	"	± 1	± 0.2	
11186	89393	7.67	0.3	F5V	10.8	11.45	0.732	64	2.2	ESA (1997)
"	"	"	"	"	"	± 1.97	"	$\pm 11^{(1)}$	$\pm 1.1^{(1)}$	
"	"	"	"	"	"	8.74	"	84	4.9	van Leeuwen (2007)
"	"	"	"	"	"	± 1.54	"	$\pm 15^{(1)}$	$\pm 2.6^{(1)}$	

⁽¹⁾ lower estimate of the error, using the parallax error only, and neglecting all the other (unknown) errors.

monitored due to the small angular separation. Indeed, at periastron $\rho = (1 - e)a \approx 0''.05$. The next periastron passage in the years 2036-2040 should enable our successors to definitely precise this orbit.

The companion has nearly the same luminosity as the primary ($\Delta m_V = 0.03$) and we can therefore assume that this system is made of two F8V stars. The dynamical parallax is in good agreement with the Hipparcos measurement and the total mass is consistent with the theoretical value (both for ESA, 1997, and van Leeuwen, 2007).

WDS 09104+6708 – STF 1306 – ADS 7203 – HIP 45038 – σ_2 UMa

This couple was discovered by W. Herschel on 1782 June 2nd and classified as H III 54, whereas it was numbered #1306 in F.G.W. Struve's catalog (Struve, 1827). More historical information can be found in Scardia (1980). This couple has a long period orbit with a high eccentricity. The observations are numerous but only cover an arc of orbit straddling the periastron passage of 1917 (see Fig. 5c). The previous orbit of Scardia (1985, last obs. 1985.27) was computed long ago and needed some revision to take ad-

vantage of the 38 new measurements made since 1985. Among those, 14 were obtained with PISCO. This couple was particularly difficult to measure because of the large magnitude difference between the two components: $\Delta m_V \approx 4$, which is close to the limit of our capabilities with the current detector of PISCO (see Fig. 1c).

A total of 223 observations have been made since its discovery in 1782. We also used an unpublished micrometer observation made by MS with the 23 cm-finder of the Ruths telescope in Merate:

1993.192 356°.4 3''.66 0.23 2 Sca Ma

(in the WDS format). The orbital elements reported in Table 2 fit the observations quite well (see Fig. 5c), with mean residuals of $\langle \Delta \rho_{O-C} \rangle = 0.114''$ and $\langle \Delta \theta_{O-C} \rangle = 1.85^\circ$. Only part of the orbit has been monitored yet, which explains the large uncertainty of the period. However, as the dispersion of the measures is quite small, the other orbital elements are rather well determined with a small uncertainty.

The value derived from our orbital elements and the Hipparcos parallax is in good agreement with the theoretical value expected for a system F7V+K2V (see

Table 11). The dynamical parallax computed with our formula (Scardia et al., 2008b) is also consistent with the Hipparcos parallax.

WDS 10269+1713 – STT 217 – ADS 7775 – HIP 51145

This couple was discovered by O Struve (1843) with the 38-cm Merz-Mahler Poulkova refractor, during his survey aiming at founding new double stars (August 1841 – December 1842). It has been regularly observed since its discovery, except during the period 1960-1970, when the angular separation was very small. Two orbits have been computed by Heintz (1963 and 1975).

ADS 7775 is also a couple that we regularly observe with PISCO (6 observations since 2004). The last orbit of Heintz (1975) is still acceptable but begins to show a systematic trend in the residuals. The most striking feature of the orbit of ADS 7775 is a very high eccentricity (one of the most highly eccentric orbits amongst the known visual binaries). The apparent orbit is also very eccentric with a lack of observations close to the periastron (see Fig. 5d). Indeed the angular separation at the periastron passage (1966.983) was very small (less than $0''.1$) which made the measurements impossible with the available instrumentation at that epoch.

From the 159 available measurements obtained since its discovery, we obtained the orbital elements reported in Table 2 that lead to mean residuals of $\langle \Delta \rho_{O-C} \rangle = 0.073''$ and $\langle \Delta \theta_{O-C} \rangle = 1.94^\circ$. Least-squares convergence could not be obtained, so we cannot give the uncertainties in this table. Clearly measurements close to the periastron are needed to constrain this orbit. But unfortunately, with a period estimated at 140 yr, the next periastron passage should occur in 2107...

The companion has a luminosity close to that of the primary ($\Delta m_V = 0.5$). We can therefore assume that this system is made of two main sequence F-type stars (see Table 11). The dynamical parallax is in good agreement with the Hipparcos measurement and the total mass is consistent with the expected theoretical value (both for ESA, 1997, and van Leeuwen, 2007).

WDS 14455+4223 – STT 285 – ADS 9378 – HIP 72153

Like STT 217, the couple STT 285 was also discovered by O Struve (1843) with the 38-cm Merz-Mahler Poulkova refractor, during his double star survey of 1841–1842. It has been regularly observed since its discovery, and the measurements are numerous. It should be noted, that in spite of the significant luminosity difference between the two components ($\Delta m_V \approx 0.8$), quadrant reversals are frequent in the position angle measurements reported by the observers. This is surprisingly also true for some recent observations with big telescopes.

Since the first orbit computed by Burnham (1891), many others have been published for this couple. The

previous orbit Couteau (1973) was still acceptable but needed some revision to profit from the 75 new accurate measurements obtained since 1973. Our new orbit of ADS 9378 was calculated by fitting the whole set of 282 observations, made since its discovery. The orbital elements reported in Table 2 fit the observations well (see Fig. 5e), with mean residuals of $0''.040$ and $2^\circ.3$ for ρ and θ , respectively. In the total list of measurements, we had to remove 28 aberrant measurements leading to residuals larger than 6° and $0''.11$.

The companion has a luminosity close to that of the primary ($\Delta m_V = 0.1$). We can therefore assume that this system is made of two F5V stars (see Table 11). The dynamical parallax is in good agreement with the Hipparcos measurement and the total mass is in agreement with the expected theoretical value (both for ESA, 1997, and van Leeuwen, 2007).

WDS 15183+2650 – STF 1932 – ADS 9578 – HIP 74893

Like STF 1037, this couple was discovered by F.G.W. Struve in Dorpat during the binary star survey he made in 1825–1827 with the Fraunhofer 25-cm refractor (Struve, 1827). ADS 9578 was first measured in July 1828 (Struve, 1837) and has been then regularly observed. The measurements are numerous. The companion has nearly completed a full revolution around the primary star since its discovery.

The last orbits computed by Heintz (1965) and Söderhjelm (1999) are still acceptable but both begin to show a systematic trend in the residuals. Taking advantage of the 41 new measurements obtained since 2000, we computed a new orbit from a total list of 576 measurements (see Fig. 6f). After rejecting 41 aberrant observations having residuals larger than 3.6 degrees in θ and 0.25 arcseconds in ρ , we obtained the final orbital elements reported in Table 2. The corresponding orbit has mean residuals of $0''.077$ and $1^\circ.4$ for ρ and θ , respectively. The computed systemic mass using Hipparcos parallax (see Table 11) is in good agreement with theoretical values. The orbital elements have small uncertainties (see Table 2) and this orbit can be considered as definitive.

The companion has a luminosity close to that of the primary ($\Delta m_V = 0.1$). We can therefore assume that this system is made of two G0V stars. The values found for $\mathfrak{M}_{\text{total}}$ are compatible with the theoretical values (see Table 11).

WDS 18146+0011 – STF 2294 – ADS 11186 – HIP 89393

Like STF 1037 and STF 1932, this couple was discovered by F.G.W. Struve in Dorpat during his 1825–1827 binary star survey with the Fraunhofer 25-cm refractor. It was first measured in July 1828 (Struve, 1837). This couple was regularly observed in the XXth century, but the measurements made in the XIXth century are scarce and scattered. The apparent orbit of

ADS 11186 has a high eccentricity with a lack of measurements close to the periastron (see Fig. 6g). Only three orbits have been computed until now, by Wilson (1933, 1935) and Luyten (1934). Taking advantage of the eighty years of measurements obtained since that epoch, we computed new orbital elements for this couple. From the 238 available observations made since its discovery in 1831, we obtained the orbital elements displayed in Table 2. They lead to mean residuals of $\langle \Delta \rho_{O-C} \rangle = 0''.078$ and $\langle \Delta \theta_{O-C} \rangle = 2''.0$. Errors could not be estimated since convergence was not reached with Hellerich's least-squares method. The representation of the observations by our orbital elements is good (especially in the plots ρ or θ versus time which are more appropriate to estimate the validity of our solution than the plot of Fig. 6g since the eccentricity of this orbit is very high). The parallax computed by van Leeuwen leads to excessive masses, but the ESA parallax gives acceptable results and is in good agreement with the dynamical parallax.

5 Conclusion

In 2013, we obtained 134 new measurements of 129 visual binaries with PISCO in Merate, with an average accuracy of $0''.01$ for the angular separation and $0^\circ.5$ for the position angles.

We also presented new orbital elements computed for ADS 1097, 5871, 7203, 7775, 9378, 9578 and 11186. Those orbits were partly derived from PISCO observations. The total mass values we have obtained are compatible with the expected theoretical values. The dynamic parallaxes computed with our revised formulae presented in Scardia et al. (2008b) are in very good agreement with Hipparcos values.

The total number of measurements made with PISCO in Merate since its installation in 2004 now exceeds 3300. Our group has thus provided a good contribution to the continuing monitoring of long period visual binary systems, which is important for refining systemic stellar masses.

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