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# Speckle observations with PISCO in Merate: XI. Astrometric measurements of visual binaries in 2010

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## ABSTRACT

We present relative astrometric measurements of visual binaries, made in 2010 with the speckle camera PISCO at the 102 cm Zeiss telescope of Brera Astronomical Observatory, in Merate. Our observing list contains orbital couples as well as binaries whose motion is still uncertain. We obtained new 207 measurements of 191 objects, with angular separations in the range  $0''.2 - 4''.7$ , and an average accuracy of  $0''.01$ . The mean error on the position angles is  $0^\circ.6$ . Most of the position angles were determined without the usual  $180^\circ$  ambiguity with the application of triple-correlation techniques and/or by inspection of the long integration files.

We also present revised orbits for ADS 5469, 8128, 8239, 10345, and new orbits for ADS 10850 and 11170, partly derived from those observations, and infer estimated values for the masses of those systems that are compatible with the spectral types.

**Key words:** binaries: close – binaries: visual — astrometry — techniques: interferometric — stars: individual (ADS 5469, ADS 8128, ADS 8239, ADS 10345, ADS 10850, ADS 11170)

## 1 INTRODUCTION

This paper deals with the results of speckle observations of visual binary stars made in Merate (Italy) in 2010 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 eleventh of a series (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, herein: Papers I to X), whose purpose is to contribute to the determination of binary orbits. 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 used there since.

We briefly describe our observations in Sect. 2. Then we present and discuss the astrometric measurements in Sect. 3. Finally in Sect. 4 we propose revised orbits for ADS 5469, 8128, 8239, 10345, and new orbits for ADS 10850 and 11170, partly derived from those observations, and discuss the estimated values for the masses of those systems.

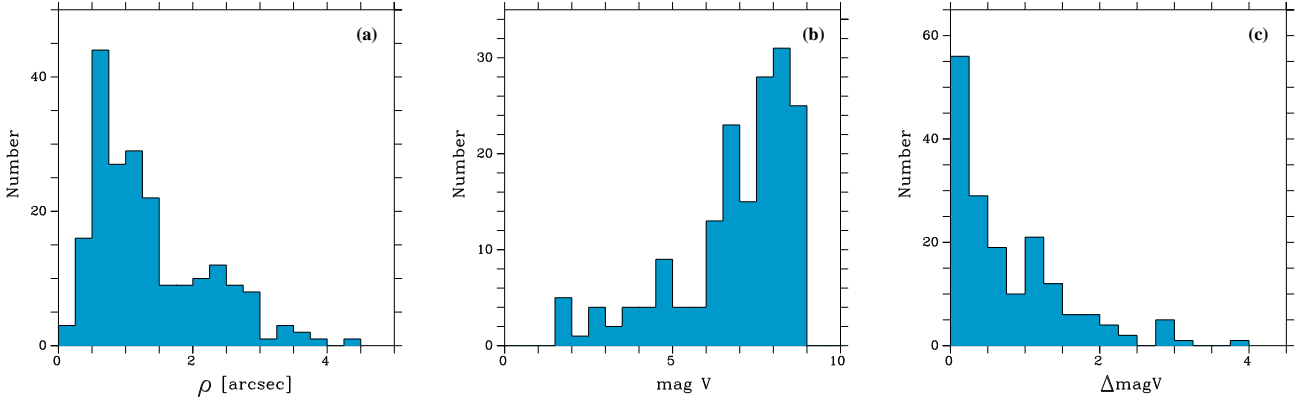
## 2 OBSERVATIONS AND DESCRIPTION OF THE OBSERVING LIST

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.

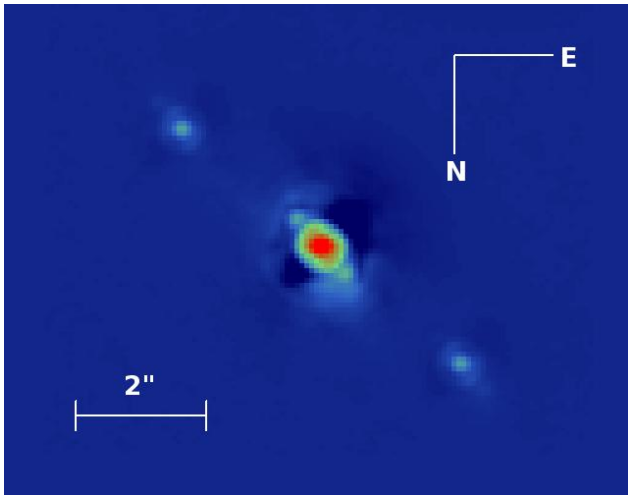
The description of our observing list can be found in our previous papers (e.g., Paper VI). It basically includes all the visual binaries for which new measurements are needed to improve their orbits, that are accessible with our instrumentation.

The distribution of the angular separations measured in this paper is displayed in Fig. 1a and shows a maximum for  $\rho \approx 0''.7$ . The largest separation of  $4''.7$  was obtained for ADS 6175. The smallest separation was measured for ADS 4229, with  $\rho = 0''.20$ . 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).

Likewise, the distribution of the apparent magnitudes  $m_V$  and of the difference of magnitudes  $\Delta m_V$  between the two components are plotted in Figs. 1b and 1c, respectively. The telescope aperture and detector sensitivity lead to a



**Figure 1.** Distribution of the angular separations of the 207 measurements of Table 1 (a), the total visual magnitudes of the 191 corresponding binaries (b) and the differences of magnitude between their two components (c).



**Figure 2.** Autocorrelation of ADS 1860 obtained from PISCO observations made on January 19th 2010 with the *I* filter. The inner and outer secondary peaks correspond to the pairs Aa,Ab ( $\rho = 0''.6$ ,  $\theta = 41^\circ$ ,  $\Delta m_V \sim 4$ ) and Aa,B ( $\rho = 2''.8$ ,  $\theta = 230^\circ$ ), respectively

limiting magnitude of about  $m_V = 9$  (Fig. 1b) and a limiting  $\Delta m_V$  of about 4.0 (Fig. 1c).

### 3 ASTROMETRIC MEASUREMENTS

The 207 astrometric measurements obtained with the observations made in 2010 are displayed in Table 1. They concern 191 binaries. For each object, we report its WDS name (Washington Double Star Catalogue, Mason et al. 2011, hereafter WDS Catalogue) 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) and the focal length of the eyepiece used for magnifying the image (Col. 6), the angular separation  $\rho$  (Col. 7) with its error (Col. 8) in arcseconds, and the position angle  $\theta$  (Col. 9) with its error (Col. 10) in degrees. In Col. 11, we report some notes and some infor-

mation about the secondary peaks of the auto-correlation files (e.g. diffuse, faint or elongated). For the systems with a known orbit, the ( $O-C$ ) (Observed minus Computed) residuals of the  $\rho$  and  $\theta$  measurements are displayed in Cols. 13 and 14, respectively. The corresponding authors are given in Col. 12, using the bibliographic style of the “Sixth Catalogue of Orbits of Visual Binary Stars” (Hartkopf & Mason, 2011, hereafter OC6). Unless explicitly specified, the measurements refer to the AB components of those systems. In Col. 14, the symbol  $^Q$  indicates that there was a quadrant inconsistency between our measures and the orbital elements published for this object.

The characteristics of the *V*, *R*, *RL* and *I* filters used for obtaining those measurements are given in Table 2. Some objects were observed with no filter because they were too faint. This is indicated with *W* (for “white” light) in the filter column (Col. 5 of Table 1). In that case, the bandpass and central wavelength correspond to that of the ICCD detector (see Prieur et al., 1998).

As for the other papers of this series, we interactively processed all the auto-correlation files computed in real time during the observations and obtained a series of measurements with different background estimates and simulated noise. The measures and errors displayed in Table 1 were derived from the mean values and the standard deviation of those multiple measurements (see Paper III for more details). The average values of the errors of the measurements reported in this table are  $0''.013 \pm 0''.009$  and  $0^\circ.64 \pm 0^\circ.50$  for  $\rho$  and  $\theta$ , respectively.

There is only one unresolved object: HO 215. We observed this object in 2004 (Paper I), 2006 (Paper V) and 2010 (this paper) (see Fig. 3). In 2006, close secondary peaks appeared in the autocorrelation after removal of a model of an unresolved star. This detection was suspicious since those peaks were nearly superimposed on the first Airy rings. Indeed those secondary peaks do not appear when processing with the same method the autocorrelations obtained in 2004 and 2010. Therefore we can now conclude that HO 215 appeared as unresolved with our instrumentation during the period 2004–2010.

**ADS 1860:** this object is known as a wide triple system (see Fig. 2). The C component ( $m_V = 9.1$ ) lies just outside the PISCO field of view at a distance of  $7''.1$ . In 2010, we

**Table 1.** PISCO measurements made in 2010 and corresponding  $O - C$  residuals (begin.)

| WDS        | Name       | ADS  | Epoch    | Fil. | Eyep.<br>(mm) | $\rho$<br>(") | $\sigma_\rho$<br>(") | $\theta$<br>( $^\circ$ ) | $\sigma_\theta$<br>( $^\circ$ ) | Notes   | Orbit    | $\Delta\rho(O-C)$<br>(") | $\Delta\theta(O-C)$<br>( $^\circ$ ) |
|------------|------------|------|----------|------|---------------|---------------|----------------------|--------------------------|---------------------------------|---------|----------|--------------------------|-------------------------------------|
| 00093+7943 | STF2       | 102  | 2010.053 | R    | 20            | 0.820         | 0.008                | 17.3*                    | 0.4                             |         | Hei1997  | -0.05                    | 0.9                                 |
| 00109+5750 | KR1        | 134  | 2010.053 | W    | 20            | 2.077         | 0.011                | 191.8*                   | 0.5                             | Elong.  |          |                          |                                     |
| 00209+1059 | BU1093     | 287  | 2010.053 | R    | 20            | 0.739         | 0.008                | 117.4*                   | 0.6                             |         | Lin2010c | -0.02                    | -0.5                                |
| 00444+3337 | STF55      | 618  | 2010.050 | W    | 20            | 2.185         | 0.013                | 330.1*                   | 0.3                             |         |          |                          |                                     |
| 00546+1911 | STT20      | 746  | 2010.050 | R    | 20            | 0.578         | 0.026                | 183.5*                   | 0.3                             |         | Doc2007d | 0.02                     | 1.4                                 |
| 00550+2338 | STF73      | 755  | 2010.050 | R    | 20            | 1.007         | 0.008                | 322.7*                   | 0.5                             |         | Mut2010b | -0.04                    | -0.6                                |
| "          | "          | "    | "        | "    | "             | "             | "                    | "                        | "                               |         | Doc1990b | -0.06                    | -0.8                                |
| 01030+4723 | STT21      | 862  | 2010.050 | R    | 20            | 1.231         | 0.011                | 174.1*                   | 0.3                             |         | Hei1966  | 0.12                     | -1.5                                |
| 01037+5026 | HU517      | 871  | 2010.053 | R    | 20            | 0.594         | 0.016                | 31.1                     | 0.7                             | Diffuse |          |                          |                                     |
| 01095+4715 | STT515     | 940  | 2010.053 | R    | 10            | 0.505         | 0.003                | 119.6*                   | 0.4                             |         | Mut2010b | -0.01                    | -0.2                                |
| "          | "          | "    | "        | "    | "             | "             | "                    | "                        | "                               |         | Sca2001d | 0.00                     | -0.5                                |
| 01112+3743 | HO215      | -    | 2010.053 | R    | 10            | -             | -                    | -                        | -                               | Unres   |          |                          |                                     |
| 01443+5732 | BU870      | 1359 | 2010.053 | RL   | 20            | 0.569         | 0.014                | 331.7*                   | 0.6                             |         | Hrt2009  | 0.03                     | 2.0                                 |
| 01593+2450 | STF194     | 1579 | 2010.088 | R    | 20            | 1.258         | 0.008                | 278.1*                   | 0.3                             |         |          |                          |                                     |
| 02020+0246 | STF202     | 1615 | 2010.050 | R    | 20            | 1.840         | 0.009                | 266.4*                   | 0.3                             |         | Sca1983f | 0.07                     | 1.8                                 |
| 02039+4220 | STT38BC    | 1630 | 2010.086 | R    | 10            | 0.219         | 0.005                | 95.7*                    | 0.9                             |         | Doc2007d | -0.02                    | -3.7                                |
| 02052-0058 | BU516      | 1645 | 2010.105 | W    | 20            | 0.677         | 0.011                | 314.6                    | 1.6                             |         |          |                          |                                     |
| 02062+2507 | STF212     | 1654 | 2010.105 | W    | 20            | 1.926         | 0.010                | 161.2*                   | 0.5                             |         |          |                          |                                     |
| 02124+3018 | STF227     | 1697 | 2010.088 | R    | 20            | 3.952         | 0.040                | 68.5*                    | 0.4                             |         |          |                          |                                     |
| 02128+3722 | HO497      | 1701 | 2010.089 | W    | 20            | 0.411         | 0.011                | 88.4*                    | 1.3                             | Elong.  |          |                          |                                     |
| 02174+6121 | STF234     | 1737 | 2010.089 | W    | 20            | 0.701         | 0.012                | 223.8*                   | 1.0                             |         | Sca1981e | 0.03                     | -1.3                                |
| 02231+7021 | MLR377     | -    | 2010.053 | R    | 20            | 0.651         | 0.017                | 140.1                    | 1.3                             |         | Pal2005b | 0.14                     | -2.6                                |
| 02291+6724 | STF262Aa,B | 1860 | 2010.053 | I    | 20            | 2.801         | 0.014                | 229.7*                   | 0.3                             |         | Hei1996b | 0.19                     | 0.4                                 |
| 02291+6724 | CHR6Aa,Ab  | 1860 | 2010.053 | I    | 20            | 0.584         | 0.020                | 41.1*                    | 1.3                             |         | Dru2003  | -0.01                    | 1.2                                 |
| 02327+0620 | STF276     | 1940 | 2010.105 | W    | 20            | 1.896         | 0.028                | 273.8                    | 0.6                             |         |          |                          |                                     |
| 02407+2637 | STT43      | 2034 | 2010.050 | W    | 20            | 0.676         | 0.014                | 346.2*                   | 0.5                             |         | Sca2001d | 0.02                     | 2.2                                 |
| "          | "          | "    | "        | "    | "             | "             | "                    | "                        | "                               |         | Hrt2001a | -0.05                    | -0.0                                |
| 02589+2137 | BU525      | 2253 | 2010.050 | W    | 20            | 0.554         | 0.023                | 92.1*                    | 0.6                             |         | Csa1978  | 0.05                     | -0.8 <sup>Q</sup>                   |
| 02592+2120 | STF333     | 2257 | 2010.050 | R    | 20            | 1.398         | 0.008                | 209.5*                   | 0.3                             |         | FMR2009c | 0.03                     | 0.1                                 |
| 03122+3713 | STF360     | 2390 | 2010.105 | W    | 20            | 2.856         | 0.018                | 124.6*                   | 0.3                             |         | WSI2004a | 0.03                     | -1.4                                |
| 03175+6540 | STT52      | 2436 | 2010.089 | R    | 10            | 0.467         | 0.009                | 58.4*                    | 1.5                             |         | Hei1998  | 0.08                     | 6.7                                 |
| 03196+6714 | HU1056     | 2452 | 2010.088 | R    | 20            | 1.082         | 0.013                | 257.7                    | 0.4                             |         |          |                          |                                     |
| 03344+2428 | STF412     | 2616 | 2010.050 | R    | 10            | 0.735         | 0.004                | 353.8                    | 0.3                             |         | Sca2002a | 0.00                     | 0.5                                 |
| 03354+3341 | STF413     | 2625 | 2010.105 | W    | 20            | 2.381         | 0.012                | 124.7*                   | 0.4                             |         |          |                          |                                     |
| 03362+4220 | A1535      | 2630 | 2010.050 | W    | 20            | 0.752         | 0.008                | 339.8                    | 1.0                             |         | Hrt2008  | 0.03                     | -0.5                                |
| "          | "          | "    | "        | "    | "             | "             | "                    | "                        | "                               |         | Mrl1970b | -0.03                    | -3.0                                |
| 03407+4601 | STT59      | 2669 | 2010.105 | W    | 20            | 2.824         | 0.021                | 355.3*                   | 0.5                             |         |          |                          |                                     |
| 03427+6950 | STF419     | 2678 | 2010.089 | R    | 20            | 2.989         | 0.015                | 72.2*                    | 0.3                             |         |          |                          |                                     |
| 03446+3210 | BU880      | 2730 | 2010.105 | W    | 20            | 0.583         | 0.008                | 16.5*                    | 1.6                             |         |          |                          |                                     |
| 03454+4952 | HU103      | 2736 | 2010.089 | R    | 20            | 1.165         | 0.014                | 202.9*                   | 1.3                             | Elong.  |          |                          |                                     |
| 03463+2411 | BU536      | 2755 | 2010.053 | W    | 20            | 0.926         | 0.015                | 178.0*                   | 0.5                             |         | Hrt2009  | -0.06                    | -1.8                                |
| 03491+3216 | STT516     | 2784 | 2010.052 | RL   | 20            | 2.221         | 0.011                | 43.4*                    | 0.3                             |         |          |                          |                                     |
| 03521+4048 | STT66      | 2815 | 2010.089 | W    | 20            | 0.975         | 0.023                | 144.4*                   | 0.7                             |         |          |                          |                                     |
| 04020+6231 | BRD1       | 2924 | 2010.105 | W    | 20            | 2.005         | 0.011                | 223.7*                   | 0.4                             |         |          |                          |                                     |
| 04115+4152 | BU546      | 3038 | 2010.089 | W    | 20            | 0.896         | 0.013                | 228.6                    | 1.0                             |         |          |                          |                                     |
| 04179+5847 | STF511     | 3098 | 2010.053 | R    | 20            | 0.535         | 0.014                | 77.4*                    | 1.2                             |         | Hei1996c | 0.03                     | -1.9                                |
| 05252+0155 | STF708     | 4012 | 2010.201 | W    | 20            | 2.695         | 0.066                | 321.1*                   | 0.3                             |         |          |                          |                                     |
| 05308+0557 | STF728     | 4115 | 2010.105 | R    | 20            | 1.237         | 0.008                | 44.5*                    | 0.8                             |         | USN1999b | -0.03                    | -0.4                                |
| 05319+2141 | COU268     | -    | 2010.201 | W    | 20            | 0.732         | 0.008                | 165.1                    | 1.0                             |         |          |                          |                                     |
| 05351+3056 | BU1267     | 4166 | 2010.201 | W    | 20            | 0.356         | 0.014                | 172.7                    | 3.6                             |         |          |                          |                                     |
| 05357+2054 | COU270     | -    | 2010.201 | W    | 20            | 0.710         | 0.012                | 41.9*                    | 2.1                             |         |          |                          |                                     |
| 05371+2655 | STF749     | 4208 | 2010.105 | R    | 20            | 1.146         | 0.008                | 140.1*                   | 0.4                             |         | Sca2007a | -0.02                    | -1.0 <sup>Q</sup>                   |
| 05381-0011 | STF757     | 4234 | 2010.195 | W    | 20            | 1.454         | 0.014                | 239.4*                   | 0.4                             | Elong.  |          |                          |                                     |
| 05386+3030 | BU1240     | 4229 | 2010.195 | R    | 10            | 0.200         | 0.003                | 327.2                    | 1.4                             | Elong.  | FMR2008  | -0.01                    | -0.1                                |
| "          | "          | "    | "        | "    | "             | "             | "                    | "                        | "                               |         | Sca1982f | -0.01                    | -1.6                                |

**Table 1.** PISCO measurements made in 2010 and corresponding  $O - C$  residuals (cont.)

| WDS        | Name        | ADS  | Epoch    | Fil. | Eyep.<br>(mm) | $\rho$<br>(") | $\sigma_\rho$<br>(") | $\theta$<br>( $^\circ$ ) | $\sigma_\theta$<br>( $^\circ$ ) | Notes   | Orbit      | $\Delta\rho(O-C)$<br>(") | $\Delta\theta(O-C)$<br>( $^\circ$ ) |
|------------|-------------|------|----------|------|---------------|---------------|----------------------|--------------------------|---------------------------------|---------|------------|--------------------------|-------------------------------------|
| 05416+1913 | STF770      | 4268 | 2010.195 | W    | 20            | 1.037         | 0.022                | 329.8*                   | 0.3                             | Elong.  |            |                          |                                     |
| 05512+5623 | A1313       | 4425 | 2010.195 | W    | 20            | 0.802         | 0.008                | 134.1*                   | 1.3                             | Faint   |            |                          |                                     |
| 05535+3720 | BU1053      | 4472 | 2010.105 | W    | 20            | 1.828         | 0.009                | 358.8*                   | 0.3                             |         |            |                          |                                     |
| 05557+6420 | HU1114      | 4479 | 2010.196 | W    | 20            | 1.289         | 0.053                | 85.6                     | 2.0                             | Faint   |            |                          |                                     |
| 05584+2938 | STF821      | 4544 | 2010.105 | W    | 20            | 2.161         | 0.011                | 3.9*                     | 0.4                             |         |            |                          |                                     |
| 06344+1445 | STF932      | 5197 | 2010.105 | W    | 20            | 1.648         | 0.014                | 306.0*                   | 0.3                             |         | Hop1960a   | 0.00                     | 3.4                                 |
| 06487+0737 | A2731       | 5469 | 2010.201 | W    | 20            | 1.291         | 0.025                | 64.4*                    | 0.4                             |         | Hei1998    | -0.11                    | -1.9                                |
| "          | "           | "    | "        | "    | "             | "             | "                    | "                        | "                               |         | This paper | 0.05                     | -0.8                                |
| 06555+3010 | STF981      | 5570 | 2010.196 | W    | 20            | 1.063         | 0.011                | 122.4*                   | 1.4                             |         | Hop1971    | -0.01                    | 4.8 <sup>Q</sup>                    |
| 07128+2713 | STF1037     | 5871 | 2010.196 | R    | 20            | 1.031         | 0.008                | 307.1                    | 1.2                             |         | Sod1999    | 0.01                     | -2.0                                |
| "          | "           | "    | "        | "    | "             | "             | "                    | "                        | "                               |         | Sca1983e   | 0.06                     | -0.4                                |
| 07303+4959 | STF1093     | 6117 | 2010.196 | W    | 20            | 0.867         | 0.018                | 202.2*                   | 0.8                             |         | Hrt2009    | -0.01                    | 0.1                                 |
| "          | "           | "    | "        | "    | "             | "             | "                    | "                        | "                               |         | Sca1984d   | 0.07                     | -0.6                                |
| 07346+3153 | STF1110     | 6175 | 2010.196 | R    | 20            | 4.746         | 0.052                | 57.4*                    | 0.3                             |         | Hei1988a   | 0.05                     | -0.3                                |
| 07401+0514 | STF1126     | 6263 | 2010.269 | R    | 20            | 0.864         | 0.008                | 173.6*                   | 1.0                             |         |            |                          |                                     |
| 07573+0108 | STT185      | 6483 | 2010.269 | RL   | 10            | 0.323         | 0.005                | 12.6                     | 1.3                             |         | Msn2009    | -0.01                    | -0.5                                |
| "          | "           | "    | "        | "    | "             | "             | "                    | "                        | "                               |         | Doc1994d   | 0.03                     | -1.7                                |
| 08024+0409 | STF1175     | 6532 | 2010.269 | W    | 20            | 1.414         | 0.019                | 282.4*                   | 0.3                             |         | Ole2001    | 0.04                     | -5.2                                |
| 08213-0136 | STF1216     | 6762 | 2010.299 | R    | 20            | 0.513         | 0.016                | 303.6                    | 0.6                             |         | Doc1994d   | 0.07                     | -1.9                                |
| 08413+2029 | BU585       | 6930 | 2010.302 | R    | 10            | 0.330         | 0.009                | 74.5                     | 1.1                             |         |            |                          |                                     |
| 08444+1555 | A2472       | 6963 | 2010.299 | W    | 20            | 0.782         | 0.020                | 81.0*                    | 0.3                             | Elong.  |            |                          |                                     |
| 08468+0625 | SP1         | 6993 | 2010.264 | R    | 10            | 0.259         | 0.004                | 154.8*                   | 0.6                             |         | Hrt1996a   | -0.00                    | -0.9                                |
| 08468+0625 | STF1273AB,C | 6993 | 2010.264 | RL   | 20            | 2.765         | 0.018                | 302.9*                   | 0.5                             |         | Hei1996b   | -0.12                    | -2.2                                |
| 08482+0235 | BU335       | 7003 | 2010.324 | W    | 20            | 2.583         | 0.023                | 264.8*                   | 0.3                             | Diffuse |            |                          |                                     |
| 08500+3935 | STF1279     | 7019 | 2010.300 | W    | 20            | 1.297         | 0.009                | 87.4*                    | 0.8                             | Elong.  |            |                          |                                     |
| 08505+2308 | AG157       | 7035 | 2010.324 | W    | 20            | 2.297         | 0.015                | 75.8*                    | 0.3                             |         |            |                          |                                     |
| 08512+0820 | PER1        | 7046 | 2010.327 | W    | 20            | 0.898         | 0.012                | 352.7*                   | 0.8                             |         |            |                          |                                     |
| 08542+3035 | STF1291     | 7071 | 2010.269 | R    | 20            | 1.506         | 0.009                | 309.5*                   | 0.3                             |         |            |                          |                                     |
| 08561+4341 | STF3120     | 7092 | 2010.302 | R    | 20            | 1.360         | 0.008                | 1.8*                     | 0.3                             |         |            |                          |                                     |
| 08571+1045 | A2968       | 7102 | 2010.302 | W    | 20            | 1.173         | 0.019                | 133.4*                   | 0.4                             | Elong.  |            |                          |                                     |
| 09033+4740 | HU720       | 7153 | 2010.269 | W    | 20            | 0.731         | 0.020                | 133.1*                   | 1.4                             | Elong.  |            |                          |                                     |
| 09036+4709 | A1585       | 7158 | 2010.264 | R    | 10            | 0.249         | 0.003                | 292.2*                   | 0.3                             |         | Mut2010b   | -0.01                    | -0.4                                |
| "          | "           | "    | "        | "    | "             | "             | "                    | "                        | "                               |         | SOR2000    | -0.01                    | 0.1                                 |
| 09104+6708 | STF1306     | 7203 | 2010.196 | RL   | 20            | 4.296         | 0.053                | 349.6*                   | 0.3                             |         | Sca1985c   | 0.14                     | -0.3                                |
| 09127+1632 | STF1322     | 7236 | 2010.264 | R    | 20            | 1.788         | 0.011                | 53.1*                    | 0.4                             |         |            |                          |                                     |
| 09136+4659 | STF1318     | 7243 | 2010.302 | W    | 20            | 2.681         | 0.044                | 229.2*                   | 0.3                             | Elong.  |            |                          |                                     |
| 09179+2834 | STF3121     | 7284 | 2010.264 | R    | 20            | 0.419         | 0.008                | 219.0*                   | 1.1                             |         | Sod1999    | -0.03                    | 1.9                                 |
| 09184+3522 | STF1333     | 7286 | 2010.264 | R    | 20            | 1.953         | 0.010                | 49.3*                    | 0.3                             |         |            |                          |                                     |
| 09188+3648 | STF1334     | 7292 | 2010.264 | RL   | 20            | 2.654         | 0.013                | 223.7*                   | 0.5                             |         |            |                          |                                     |
| 09208+6121 | STF1331     | 7300 | 2010.270 | W    | 20            | 0.897         | 0.009                | 151.9*                   | 0.9                             | Elong.  |            |                          |                                     |
| 09210+3643 | STF1339     | 7308 | 2010.302 | W    | 20            | 1.424         | 0.020                | 64.5*                    | 0.5                             | Elong.  |            |                          |                                     |
| 09210+3811 | STF1338     | 7307 | 2010.196 | R    | 20            | 1.089         | 0.010                | 300.6*                   | 1.0                             |         | Sca2002b   | -0.03                    | -0.8                                |
| 09239+2754 | STT201      | 7344 | 2010.300 | W    | 20            | 1.258         | 0.011                | 205.8*                   | 0.3                             | Elong.  |            |                          |                                     |
| 09252+1449 | HU869       | 7359 | 2010.327 | W    | 20            | 0.762         | 0.008                | 272.8*                   | 0.7                             |         |            |                          |                                     |
| 09277+1545 | STF1353     | 7386 | 2010.327 | W    | 20            | 3.256         | 0.017                | 126.0                    | 0.3                             |         |            |                          |                                     |
| 09277+4456 | A1762       | 7378 | 2010.300 | W    | 20            | 0.762         | 0.011                | 106.2                    | 0.6                             | Elong.  |            |                          |                                     |
| 09285+0903 | STF1356     | 7390 | 2010.196 | R    | 10            | 0.738         | 0.010                | 102.7*                   | 0.6                             |         | Mut2010b   | -0.00                    | -0.4                                |
| "          | "           | "    | "        | "    | "             | "             | "                    | "                        | "                               |         | vDl1976    | -0.00                    | -0.9                                |
| 09290+1917 | COU936      | -    | 2010.327 | W    | 20            | 0.879         | 0.008                | 226.3*                   | 1.1                             |         |            |                          |                                     |
| 09300+4216 | A1985       | 7398 | 2010.196 | W    | 20            | 1.553         | 0.008                | 24.8                     | 1.1                             |         |            |                          |                                     |
| 09414+3857 | STF1374     | 7477 | 2010.264 | R    | 20            | 2.832         | 0.014                | 308.8*                   | 0.5                             |         |            |                          |                                     |
| 09435+0612 | A2761       | 7499 | 2010.324 | W    | 20            | 1.026         | 0.018                | 250.8*                   | 0.4                             | Elong.  |            |                          |                                     |
| 09476+5057 | HU630       | 7514 | 2010.324 | W    | 20            | 2.215         | 0.022                | 73.2*                    | 0.3                             |         |            |                          |                                     |
| 09513+6037 | STF1381     | 7536 | 2010.270 | W    | 20            | 0.847         | 0.009                | 186.9*                   | 0.8                             |         |            |                          |                                     |
| 09521+5404 | STT208      | 7545 | 2010.264 | R    | 10            | 0.357         | 0.003                | 292.9*                   | 0.4                             |         | Hei1996c   | -0.02                    | -1.9                                |
| 10056+3105 | STF1406     | 7632 | 2010.270 | W    | 20            | 0.767         | 0.008                | 218.4*                   | 0.6                             | Elong.  |            |                          |                                     |
| 10057+4103 | A2142       | 7631 | 2010.264 | R    | 20            | 1.055         | 0.008                | 294.9*                   | 0.3                             |         |            |                          |                                     |
| 10151+1907 | STF1417     | 7695 | 2010.270 | W    | 20            | 2.329         | 0.013                | 76.4                     | 0.3                             |         |            |                          |                                     |
| 10163+1744 | STT215      | 7704 | 2010.264 | R    | 20            | 1.461         | 0.011                | 177.6*                   | 0.3                             |         | Zae1984    | -0.08                    | -1.6                                |

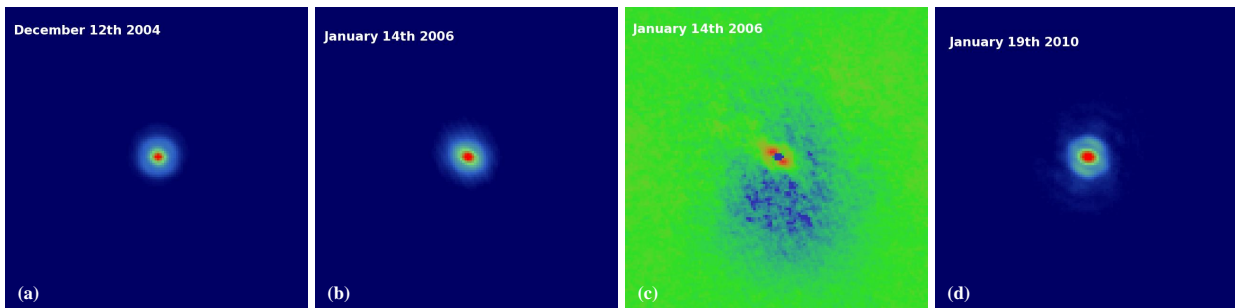
**Table 1.** PISCO measurements made in 2010 and corresponding  $O - C$  residuals (cont.)

| WDS        | Name    | ADS  | Epoch    | Fil. | Eyep.<br>(mm) | $\rho$<br>(") | $\sigma_\rho$<br>(") | $\theta$<br>( $^\circ$ ) | $\sigma_\theta$<br>( $^\circ$ ) | Notes   | Orbit      | $\Delta\rho(O-C)$<br>(") | $\Delta\theta(O-C)$<br>( $^\circ$ ) |
|------------|---------|------|----------|------|---------------|---------------|----------------------|--------------------------|---------------------------------|---------|------------|--------------------------|-------------------------------------|
| 10205+0626 | STF1426 | 7730 | 2010.270 | R    | 20            | 0.911         | 0.008                | 310.6                    | 0.5                             |         | Sca2008c   | 0.01                     | -0.8                                |
| "          | "       | "    | "        | "    | "             | "             | "                    | "                        | "                               |         | Nov2006    | -0.01                    | -0.8                                |
| 10279+3642 | HU879   | 7780 | 2010.300 | R    | 10            | 0.523         | 0.004                | 223.7*                   | 0.6                             | Elong.  | Msn2001c   | 0.00                     | 0.8                                 |
| 10397+0851 | STT224  | 7871 | 2010.300 | R    | 20            | 0.510         | 0.011                | 139.5                    | 0.6                             | Faint   | Hrt2010a   | -0.00                    | -1.7                                |
| 10426+0335 | A2768   | 7896 | 2010.324 | R    | 20            | 0.613         | 0.018                | 250.0*                   | 0.6                             |         | Hrt2010a   | 0.02                     | 0.2                                 |
| 10480+4107 | STT229  | 7929 | 2010.324 | R    | 20            | 0.677         | 0.011                | 262.2                    | 1.0                             |         | Alz1998a   | 0.02                     | 1.0                                 |
| 11000-0328 | STF1500 | 8007 | 2010.387 | R    | 20            | 1.370         | 0.015                | 299.9                    | 0.3                             |         |            |                          |                                     |
| 11037+6145 | BU1077  | 8035 | 2010.264 | V    | 10            | 0.586         | 0.003                | 17.8*                    | 0.3                             |         | Sca2010d   | -0.01                    | -1.4                                |
| "          | "       | "    | 2010.324 | V    | 10            | 0.588         | 0.003                | 17.2*                    | 0.5                             |         | Sca2010d   | -0.01                    | -1.6                                |
| "          | "       | "    | 2010.327 | V    | 10            | 0.597         | 0.004                | 17.7*                    | 0.3                             |         | Sca2010d   | 0.00                     | -1.1                                |
| "          | "       | "    | 2010.384 | V    | 10            | 0.592         | 0.006                | 17.7*                    | 0.7                             |         | Sca2010d   | -0.00                    | -0.7                                |
| 11050+3825 | HO378   | 8047 | 2010.387 | R    | 20            | 1.058         | 0.012                | 237.2                    | 0.3                             |         |            |                          |                                     |
| 11154+2734 | STF1521 | 8105 | 2010.392 | R    | 20            | 3.678         | 0.035                | 96.8*                    | 0.3                             |         |            |                          |                                     |
| 11158+4227 | COU1904 | -    | 2010.327 | W    | 20            | 0.459         | 0.016                | 213.4                    | 1.0                             |         |            |                          |                                     |
| 11190+1416 | STF1527 | 8128 | 2010.264 | R    | 10            | 0.310         | 0.003                | 186.0*                   | 0.3                             |         | Pru2009    | 0.08                     | -7.2                                |
| "          | "       | "    | "        | "    | "             | "             | "                    | "                        | "                               | "       | This paper | -0.00                    | -0.4                                |
| "          | "       | "    | 2010.300 | R    | 10            | 0.326         | 0.003                | 187.0                    | 0.4                             | Faint   | Pru2009    | 0.10                     | -7.0                                |
| "          | "       | "    | "        | "    | "             | "             | "                    | "                        | "                               | "       | This paper | 0.01                     | 0.2                                 |
| "          | "       | "    | 2010.324 | R    | 10            | 0.317         | 0.003                | 187.5                    | 0.8                             | "       | Pru2009    | 0.09                     | -7.1                                |
| "          | "       | "    | "        | "    | "             | "             | "                    | "                        | "                               | "       | This paper | 0.01                     | 0.4                                 |
| "          | "       | "    | 2010.327 | R    | 10            | 0.318         | 0.005                | 188.2                    | 0.3                             | NF      | Pru2009    | 0.09                     | -6.4                                |
| "          | "       | "    | "        | "    | "             | "             | "                    | "                        | "                               | "       | This paper | 0.01                     | 1.0                                 |
| "          | "       | "    | 2010.384 | R    | 10            | 0.318         | 0.005                | 187.6                    | 0.6                             | "       | Pru2009    | 0.10                     | -8.4                                |
| "          | "       | "    | "        | "    | "             | "             | "                    | "                        | "                               | "       | This paper | 0.01                     | -0.3                                |
| "          | "       | "    | 2010.395 | R    | 10            | 0.323         | 0.003                | 186.5*                   | 0.4                             | "       | Pru2009    | 0.10                     | -9.8                                |
| "          | "       | "    | "        | "    | "             | "             | "                    | "                        | "                               | "       | This paper | 0.01                     | -1.6                                |
| 11245+2037 | STF1537 | 8149 | 2010.393 | W    | 20            | 2.266         | 0.011                | 358.0*                   | 0.4                             |         |            |                          |                                     |
| 11267+6654 | HU1133  | 8159 | 2010.395 | W    | 20            | 0.781         | 0.008                | 346.4*                   | 0.8                             |         |            |                          |                                     |
| 11332+4927 | HU727   | 8210 | 2010.300 | W    | 20            | 1.256         | 0.008                | 203.5                    | 0.5                             | Elong.  |            |                          |                                     |
| 11371+4040 | A1996   | 8241 | 2010.393 | W    | 20            | 2.011         | 0.023                | 189.5                    | 0.7                             |         |            |                          |                                     |
| 11406+2102 | STF1566 | 8263 | 2010.393 | W    | 20            | 2.382         | 0.012                | 349.7*                   | 0.4                             |         |            |                          |                                     |
| 11428+2105 | HU888   | 8275 | 2010.393 | W    | 20            | 0.550         | 0.008                | 175.9*                   | 0.4                             |         |            |                          |                                     |
| 11431+3715 | HU1135  | 8276 | 2010.393 | W    | 20            | 0.695         | 0.008                | 335.3                    | 0.7                             |         |            |                          |                                     |
| 11517+4449 | HJ842   | 8324 | 2010.387 | W    | 20            | 3.150         | 0.016                | 88.6*                    | 0.8                             | Elong.  |            |                          |                                     |
| 11547+0944 | BRT1276 | -    | 2010.395 | W    | 20            | 2.875         | 0.014                | 358.2*                   | 0.3                             |         |            |                          |                                     |
| 11563+3527 | STT241  | 8355 | 2010.387 | R    | 20            | 1.802         | 0.009                | 144.7*                   | 0.6                             |         |            |                          |                                     |
| 11598+5324 | STT243  | 8378 | 2010.387 | W    | 20            | 1.217         | 0.013                | 8.9*                     | 0.3                             |         |            |                          |                                     |
| 12126+3546 | STF1613 | 8460 | 2010.395 | W    | 20            | 1.162         | 0.008                | 7.3                      | 0.4                             |         |            |                          |                                     |
| 12291+3123 | STT251  | 8569 | 2010.327 | W    | 20            | 0.724         | 0.008                | 58.3*                    | 0.8                             |         | Sca2003c   | 0.06                     | -2.0                                |
| 12329+5448 | A1600   | 8594 | 2010.396 | W    | 20            | 0.837         | 0.015                | 8.3*                     | 0.7                             |         |            |                          |                                     |
| 12417-0127 | STF1670 | 8630 | 2010.300 | R    | 20            | 1.440         | 0.008                | 22.2*                    | 0.3                             |         | Sca2007c   | -0.01                    | 0.2                                 |
| "          | "       | "    | 2010.324 | R    | 20            | 1.433         | 0.008                | 22.5*                    | 0.5                             |         | Sca2007c   | -0.02                    | 0.7                                 |
| "          | "       | "    | 2010.384 | R    | 20            | 1.468         | 0.009                | 21.8*                    | 0.7                             |         | Sca2007c   | -0.00                    | 0.3                                 |
| "          | "       | "    | 2010.426 | R    | 20            | 1.467         | 0.010                | 21.1*                    | 0.3                             |         | Sca2007c   | -0.01                    | -0.2                                |
| 12438+0733 | STF1674 | 8646 | 2010.387 | W    | 20            | 2.322         | 0.013                | 173.5*                   | 0.7                             |         |            |                          |                                     |
| 12533+1310 | HU894   | 8696 | 2010.396 | W    | 20            | 1.188         | 0.008                | 143.9*                   | 0.3                             |         |            |                          |                                     |
| 12533+2115 | STF1687 | 8695 | 2010.387 | RL   | 20            | 1.132         | 0.008                | 192.9*                   | 0.5                             |         | Hei1997    | 0.10                     | -2.8                                |
| 12564-0057 | STT256  | 8708 | 2010.327 | R    | 20            | 1.072         | 0.008                | 99.0                     | 0.3                             |         |            |                          |                                     |
| 12574+3022 | STF1696 | 8716 | 2010.324 | W    | 20            | 3.631         | 0.056                | 203.7*                   | 0.4                             | Diffuse |            |                          |                                     |
| 13007+5622 | BU1082  | 8739 | 2010.324 | RL   | 20            | 1.069         | 0.010                | 101.8*                   | 0.3                             |         | Sod1999    | 0.01                     | -2.2                                |
| 13100+1732 | STF1728 | 8804 | 2010.445 | R    | 10            | 0.633         | 0.003                | 12.3                     | 0.3                             |         | Mut2010b   | -0.01                    | 0.1                                 |
| "          | "       | "    | "        | "    | "             | "             | "                    | "                        | "                               | "       | WSI2006b   | -0.01                    | 0.0                                 |
| 13101+3830 | BU608BC | 8805 | 2010.387 | RL   | 20            | 1.288         | 0.015                | 267.4*                   | 0.6                             |         |            |                          |                                     |
| 13120+3205 | STT261  | 8814 | 2010.387 | R    | 20            | 2.554         | 0.013                | 338.4*                   | 0.5                             |         |            |                          |                                     |
| 13166+5034 | STT263  | 8843 | 2010.393 | W    | 20            | 1.743         | 0.009                | 136.1*                   | 0.3                             |         |            |                          |                                     |
| 13207+0257 | STF1734 | 8864 | 2010.387 | R    | 20            | 1.106         | 0.012                | 174.4*                   | 0.8                             |         |            |                          |                                     |
| 13235+2914 | HO260   | 8887 | 2010.393 | W    | 20            | 1.573         | 0.011                | 85.5*                    | 0.3                             |         | WSI2004a   | -0.06                    | 0.9                                 |
| 13288+5956 | STF1752 | 8919 | 2010.396 | W    | 20            | 0.968         | 0.017                | 107.9*                   | 0.4                             |         |            |                          |                                     |
| 13329+4908 | STF1758 | 8940 | 2010.396 | W    | 20            | 3.389         | 0.017                | 291.6*                   | 0.3                             | Elong.  |            |                          |                                     |
| 13340+0847 | A1792   | 8946 | 2010.385 | W    | 20            | 0.713         | 0.030                | 306.4*                   | 0.7                             |         |            |                          |                                     |

**Table 1.** PISCO measurements made in 2010 and corresponding  $O - C$  residuals (cont.)

| WDS        | Name         | ADS   | Epoch    | Fil. | Eyep.<br>(mm) | $\rho$<br>(") | $\sigma_\rho$<br>(") | $\theta$<br>( $^\circ$ ) | $\sigma_\theta$<br>( $^\circ$ ) | Notes   | Orbit      | $\Delta\rho(O-C)$<br>(") | $\Delta\theta(O-C)$<br>( $^\circ$ ) |
|------------|--------------|-------|----------|------|---------------|---------------|----------------------|--------------------------|---------------------------------|---------|------------|--------------------------|-------------------------------------|
| 13346+3308 | BU933        | 8958  | 2010.396 | W    | 20            | 2.759         | 0.014                | 22.5*                    | 0.3                             |         |            |                          |                                     |
| 13356+4939 | AG190        | 8964  | 2010.426 | W    | 20            | 2.632         | 0.013                | 12.3*                    | 0.5                             |         |            |                          |                                     |
| 13571+3426 | BU937        | 9067  | 2010.393 | W    | 20            | 1.040         | 0.011                | 134.3*                   | 0.5                             |         |            |                          |                                     |
| 13577+5200 | A1614        | 9071  | 2010.396 | W    | 20            | 1.399         | 0.008                | 300.9*                   | 0.3                             |         | Hei2001    | -0.06                    | -2.0 <sup>Q</sup>                   |
| 13598+1953 | STF1794      | 9078  | 2010.426 | W    | 20            | 1.897         | 0.012                | 125.9*                   | 0.3                             |         |            |                          |                                     |
| 14101+2636 | STF1808      | 9136  | 2010.426 | W    | 20            | 2.604         | 0.017                | 81.5*                    | 0.3                             | Elong.  |            |                          |                                     |
| 14116+2802 | STF1810      | 9150  | 2010.426 | W    | 20            | 2.315         | 0.012                | 183.7*                   | 0.6                             | Elong.  |            |                          |                                     |
| 14184+3412 | HU901        | 9214  | 2010.426 | W    | 20            | 0.571         | 0.008                | 35.5*                    | 0.9                             |         |            |                          |                                     |
| 14203+4830 | STF1834      | 9229  | 2010.393 | R    | 20            | 1.589         | 0.011                | 102.0                    | 0.3                             |         | USN2000c   | 0.04                     | -1.5                                |
| 14220+5107 | A148         | 9238  | 2010.393 | R    | 20            | 0.556         | 0.008                | 7.7                      | 1.1                             |         |            |                          |                                     |
| 14234+4736 | A149         | 9249  | 2010.426 | W    | 20            | 0.803         | 0.014                | 120.0*                   | 0.6                             |         |            |                          |                                     |
| 14369+4813 | A347         | 9324  | 2010.540 | W    | 20            | 0.562         | 0.021                | 62.8*                    | 1.2                             | Elong.  | Doc2004a   | -0.01                    | -0.8 <sup>Q</sup>                   |
| 14380+5135 | STF1863      | 9329  | 2010.540 | R    | 20            | 0.659         | 0.019                | 59.6                     | 1.1                             |         |            |                          |                                     |
| 14407+3117 | STF1867      | 9340  | 2010.541 | W    | 20            | 0.702         | 0.008                | 355.9*                   | 0.8                             | Elong.  |            |                          |                                     |
| 14411+1344 | STF1865      | 9343  | 2010.538 | R    | 10            | 0.548         | 0.003                | 294.4                    | 0.3                             |         | Mut2010b   | -0.00                    | 0.1                                 |
| "          | "            | "     | "        | "    | "             | "             | "                    | "                        | "                               |         | Sta1980a   | -0.11                    | -2.1                                |
| 14417+0932 | STF1866      | 9345  | 2010.541 | W    | 20            | 0.740         | 0.008                | 203.5*                   | 1.2                             |         |            |                          |                                     |
| 14489+0557 | STF1883      | 9392  | 2010.546 | W    | 20            | 0.952         | 0.018                | 279.5                    | 0.3                             |         | USN2000c   | 0.00                     | 1.3                                 |
| 15183+2650 | STF1932      | 9578  | 2010.538 | R    | 20            | 1.614         | 0.008                | 263.7                    | 0.3                             |         | Hei1965c   | -0.02                    | 0.0                                 |
| 15245+3723 | STF1938Ba,Bb | 9626  | 2010.538 | R    | 20            | 2.269         | 0.011                | 5.5*                     | 0.3                             |         | Sod1999    | 0.02                     | 0.5                                 |
| "          | "            | "     | "        | "    | "             | "             | "                    | "                        | "                               |         | Sca1986b   | 0.04                     | 0.2                                 |
| 15257+2638 | STF1941      | 9630  | 2010.582 | W    | 20            | 1.373         | 0.011                | 213.0*                   | 0.3                             |         |            |                          |                                     |
| 15277+0606 | STF1944      | 9647  | 2010.546 | W    | 20            | 0.707         | 0.008                | 298.4*                   | 0.9                             |         |            |                          |                                     |
| 15485+2600 | COU616       | -     | 2010.582 | W    | 20            | 0.761         | 0.012                | 160.7*                   | 0.9                             |         |            |                          |                                     |
| 15498+4431 | BU621        | 9802  | 2010.541 | W    | 20            | 0.703         | 0.008                | 27.4*                    | 0.3                             | Diffuse |            |                          |                                     |
| 15509+1911 | A2078        | 9809  | 2010.541 | W    | 20            | 1.089         | 0.019                | 166.3*                   | 0.6                             |         |            |                          |                                     |
| 16009+1316 | STT303       | 9880  | 2010.538 | R    | 20            | 1.558         | 0.008                | 173.0*                   | 0.3                             |         |            |                          |                                     |
| 16071+1654 | BU812        | 9925  | 2010.601 | W    | 20            | 0.698         | 0.008                | 97.1*                    | 1.0                             |         |            |                          |                                     |
| 16112+4734 | STF2025      | 9956  | 2010.601 | W    | 20            | 2.555         | 0.013                | 163.3*                   | 0.3                             |         |            |                          |                                     |
| 16115+1507 | A1799        | 9952  | 2010.582 | W    | 20            | 0.752         | 0.008                | 116.4*                   | 1.0                             |         |            |                          |                                     |
| 16160+0721 | STF2026      | 9982  | 2010.538 | W    | 20            | 3.450         | 0.017                | 17.7*                    | 0.3                             | Elong.  | Sca2010d   | 0.02                     | -0.1                                |
| 16188+1724 | STF2037      | 9997  | 2010.582 | W    | 20            | 1.188         | 0.023                | 252.8                    | 0.3                             |         |            |                          |                                     |
| 16289+1825 | STF2052      | 10075 | 2010.538 | R    | 20            | 2.251         | 0.011                | 120.3*                   | 0.3                             |         | Lmp2001a   | 0.01                     | 0.4                                 |
| "          | "            | "     | "        | "    | "             | "             | "                    | "                        | "                               |         | Sod1999    | 0.03                     | 0.1                                 |
| "          | "            | "     | "        | "    | "             | "             | "                    | "                        | "                               |         | Sca1984d   | -0.01                    | -0.6                                |
| 16422+4112 | STF2091      | 10169 | 2010.601 | W    | 20            | 0.363         | 0.024                | 324.4*                   | 2.6                             |         |            |                          |                                     |
| 16433+2508 | STF2089      | 10174 | 2010.601 | W    | 20            | 2.701         | 0.016                | 60.7*                    | 0.3                             |         |            |                          |                                     |
| 16511+0924 | STF2106      | 10229 | 2010.538 | R    | 20            | 0.738         | 0.008                | 172.1*                   | 0.7                             |         | Sca2001g   | -0.02                    | -0.1                                |
| 16564+6502 | STF2118      | 10279 | 2010.538 | R    | 20            | 1.035         | 0.008                | 66.2*                    | 0.4                             |         | Sca2002d   | -0.12                    | -0.9                                |
| 17020+0827 | STF2114      | 10312 | 2010.538 | R    | 20            | 1.315         | 0.008                | 194.9*                   | 0.3                             |         |            |                          |                                     |
| 17053+5428 | STF2130      | 10345 | 2010.538 | R    | 20            | 2.414         | 0.012                | 7.6*                     | 0.3                             |         | Hei1981b   | 0.05                     | 2.1                                 |
| "          | "            | "     | "        | "    | "             | "             | "                    | "                        | "                               |         | This paper | 0.01                     | -1.6                                |
| 17055+1033 | BU357        | 10336 | 2010.601 | W    | 20            | 1.458         | 0.008                | 305.4*                   | 0.8                             |         |            |                          |                                     |
| 17096+0356 | HEI894       | -     | 2010.601 | W    | 20            | 0.559         | 0.027                | 24.3*                    | 2.1                             |         |            |                          |                                     |
| 17175+3205 | BU629        | 10450 | 2010.601 | W    | 20            | 1.188         | 0.008                | 339.1*                   | 0.6                             |         |            |                          |                                     |
| 17178+4535 | STF2152      | 10458 | 2010.669 | W    | 20            | 1.948         | 0.016                | 237.3*                   | 0.3                             | Elong.  |            |                          |                                     |
| 17179+4918 | STF2153      | 10460 | 2010.669 | W    | 20            | 1.477         | 0.011                | 245.3*                   | 0.4                             | Elong.  |            |                          |                                     |
| 17457+1743 | STF2205      | 10769 | 2010.582 | W    | 20            | 1.013         | 0.008                | 3.1*                     | 0.5                             |         | Cve2008a   | -0.04                    | 0.1                                 |
| 17479+1449 | STF2222      | 10803 | 2010.669 | W    | 20            | 2.290         | 0.011                | 61.9*                    | 0.3                             |         |            |                          |                                     |
| 17518+2814 | STF2239      | 10851 | 2010.669 | W    | 20            | 2.423         | 0.012                | 318.3*                   | 0.3                             |         |            |                          |                                     |
| 17520+1520 | STT338       | 10850 | 2010.669 | R    | 20            | 0.818         | 0.008                | 164.3*                   | 0.4                             |         | This paper | -0.01                    | -0.9                                |
| 17531+4212 | COU1599      | -     | 2010.669 | W    | 20            | 0.594         | 0.021                | 125.8*                   | 3.9                             |         |            |                          |                                     |
| 17567+4837 | STF2258      | 10924 | 2010.669 | W    | 20            | 2.090         | 0.010                | 221.0*                   | 0.4                             |         |            |                          |                                     |
| 19143+1904 | STF2484      | 12201 | 2010.669 | W    | 20            | 2.130         | 0.011                | 239.4*                   | 0.5                             |         | Hop1973b   | -0.14                    | 0.3                                 |
| 19148+4756 | A706         | 12229 | 2010.669 | W    | 20            | 1.570         | 0.008                | 73.2*                    | 0.3                             |         |            |                          |                                     |
| 19251+1839 | HU339        | 12416 | 2010.669 | W    | 20            | 0.825         | 0.018                | 246.0*                   | 0.5                             |         |            |                          |                                     |
| 19261+3849 | HO450        | 12446 | 2010.669 | W    | 20            | 0.971         | 0.014                | 262.4*                   | 0.9                             |         |            |                          |                                     |
| 19266+2719 | STF2525      | 12447 | 2010.669 | W    | 20            | 2.135         | 0.011                | 289.0*                   | 0.3                             |         | Hei1984b   | 0.02                     | -0.9                                |

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



**Figure 3.** HO215: autocorrelations obtained with PISCO observations in 2004 (a), 2006 (b) and 2010 (d). The observations of 2006 suggested the existence of a companion when removing a model of unresolved star (c), but this was not confirmed by the observations of 2004 and 2010.

**Table 2.** Characteristics of the filters used for the measurements of Table 1.

| Name | Identification | $\lambda_c$<br>(nm) | $\Delta_\lambda$<br>(nm) |
|------|----------------|---------------------|--------------------------|
| V    | ORIEL/57581    | 530                 | 57                       |
| R    | ORIEL/57621    | 644                 | 70                       |
| RL   | ORIEL/57661    | 743                 | 69                       |
| I    | ORIEL/57701    | 855                 | 67                       |
| W    | ICCD alone     | 650                 | 420                      |

measured the Aa,B and Aa,Ab pairs, with  $\rho = 2''.801$  and  $\rho = 0''.584$ , respectively. The closest pair (CHR 6 Aa) is an orbital couple with a period of 46 years and a very large difference of luminosity in  $V$ :  $\Delta m_V \sim 4$ . The primary is an A5 star and the companion must be a cool star. In order to reduce the contrast between the two components, we observed this object with the  $I$  filter.

### 3.1 Quadrant determination

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

As a result, in Table 1, we are able to give the unambiguous (i.e. “absolute”) position angles of 165 out of 207 measurements, i.e. 80% of the total. They are marked with an asterisk in Col 9. Otherwise, our angular measurements were reduced to the quadrant reported in the WDS catalogue, which is extracted from the Fourth Catalogue of Interferometric Measurements of Binary Stars (Hartkopf et al. 2011, hereafter IC4).

Our “absolute”  $\theta$  values are consistent with the values tabulated in WDS for all objects except for ADS 2253, 4208, 6963 and 9324. We display some parameters of all those objects in Table 3. In Col. 2, we indicate the quadrant (Q) we

**Table 3.** Objects with discrepant quadrants

| Name     | Q | Filter | $\Delta m_V$ | Spectral type |
|----------|---|--------|--------------|---------------|
| ADS 2253 | 2 | W      | 0.1          | A3            |
| ADS 4208 | 2 | R      | 0.05         | B8 IV         |
| ADS 6963 | 1 | W      | 0.04         | A2            |
| ADS 9324 | 1 | W      | 0.2          | F2            |

found with the RTC, using the usual convention of numbering them from 1 to 4 to indicate the North-East, South-East, South-West and North-West quadrants, respectively. In Col. 3 we recall the filter we have used ( $W$  indicates the absence of filter: the corresponding central wavelength is close that of the  $R$  filter). In Col. 4, we give the differences of magnitude between the two components from the IC4, and in Col. 5 the global spectral types found in the SIMBAD astronomical data base.

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

### 3.2 Comparison with published ephemerides

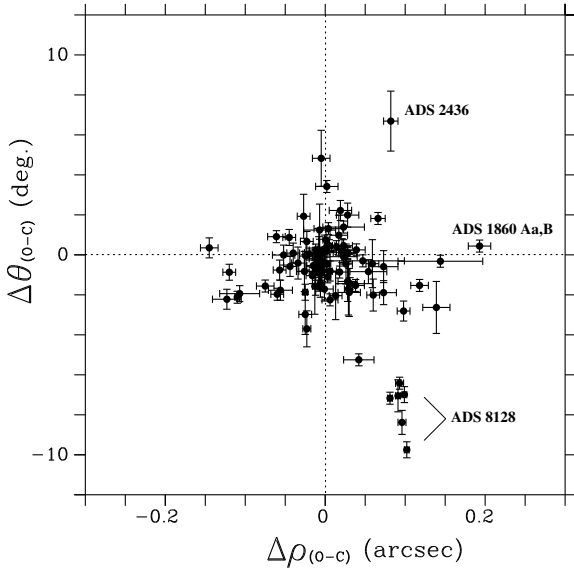
The  $(O - C)$  (Observed minus Computed) residuals of the measurements for the 72 systems with a known orbit in Table 1 are displayed in Cols. 13 and 14 for the separation  $\rho$  and position angle  $\theta$ , respectively.

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

For ADS 5469, 8128, 10345 and 10850 we also reported the residuals obtained with our new orbits presented in Sect. 4.

Fig. 4 shows that the residuals have a rather large scatter that can be explained by the (old) age of many orbits. The mean values computed with the residuals of Table 1 are  $\langle \Delta \rho_{O-C} \rangle = -0''.01 \pm 0''.06$  and  $\langle \Delta \theta_{O-C} \rangle = -0^\circ.9 \pm 2^\circ.3$ .





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

In the following, we examine the cases of ADS 1860 Aa-B, 2436 and 8128, that appear with the largest residuals in Fig. 4.

**ADS 1860 (STF262 Aa-B) and ADS 2436:** The orbits of Heintz (1996) for STF262 Aa-B and Heintz (1998) for ADS 2436 are preliminary. The arcs of orbit are still short ( $58^\circ$  and  $97^\circ$ , for STF262 Aa-B and ADS 2436, respectively) and have a small curvature. Hence, their orbital periods are likely to be very long (about 1400 and 400 years, respectively) and it is still too premature to revise Heintz’ orbits. Clearly new measurements are needed to improve the quality of those orbits.

**ADS 8128:** its periastron passage occurred in the beginning of 2010 and our last orbit (Prieur et al, 2009) leads to rather large residuals in theta (close to  $-7^\circ$ ). We propose a new orbit in Sect. 4.2.

#### 4 REVISED ORBITS OF ADS 5469, 8128, 8239, 10345, AND NEW ORBITS FOR ADS 10850 AND 11170

In this section we present the new orbits we have computed for ADS 5469, 8128, 8239, 10345, 10850 and 11170.

We have followed the same method for those six 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 4. The description of the format of the tables contained in this section can be found in Papers VI and VII. The errors reported for ADS 5469, 8128, 8239 and 10345 were obtained by Hellerich’s least-squares method. For ADS 10850 and 11170, this method failed to converge, which explains the absence of errors for those orbits.

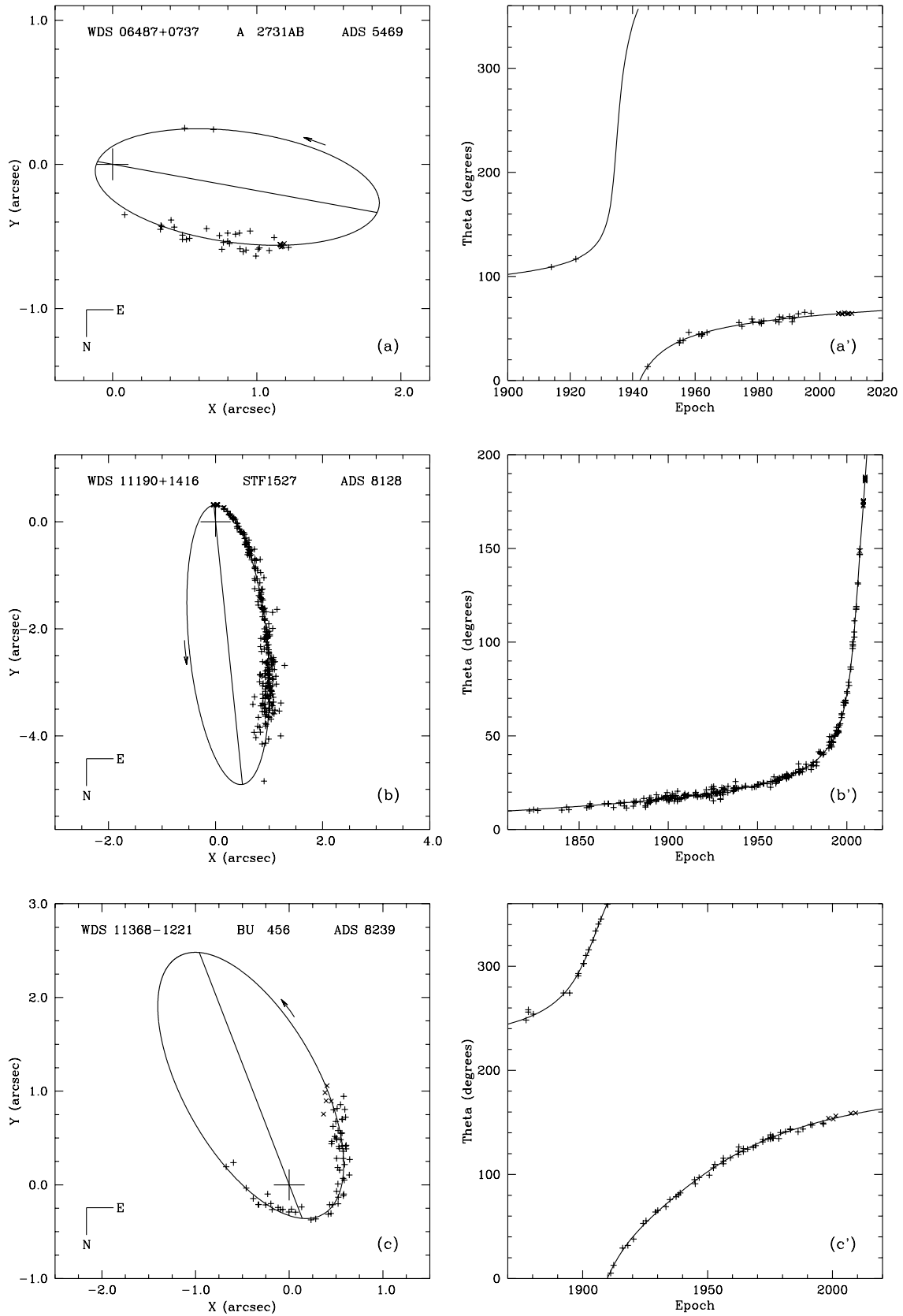
The corresponding ( $O - C$ ) residuals, restricted to the last observations for reasons of space, are given in Tables 5, 6, 7, 8, 9 and 10 for ADS 5469, 8128, 8239, 10345, 10850, and 11170 respectively. In the last column, we report the name of the observer, using the US Naval Observatory convention.

The ephemerides for 2012–2021 are presented in Table 11. The apparent orbits are shown in Fig. 5a,b,c and 6a,b,c as solid lines. The observational data used for the calculation of the orbital elements are plotted as small crosses. The orientation of the graphs conforms to the convention adopted by the observers of visual binary stars. For each object, the 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.

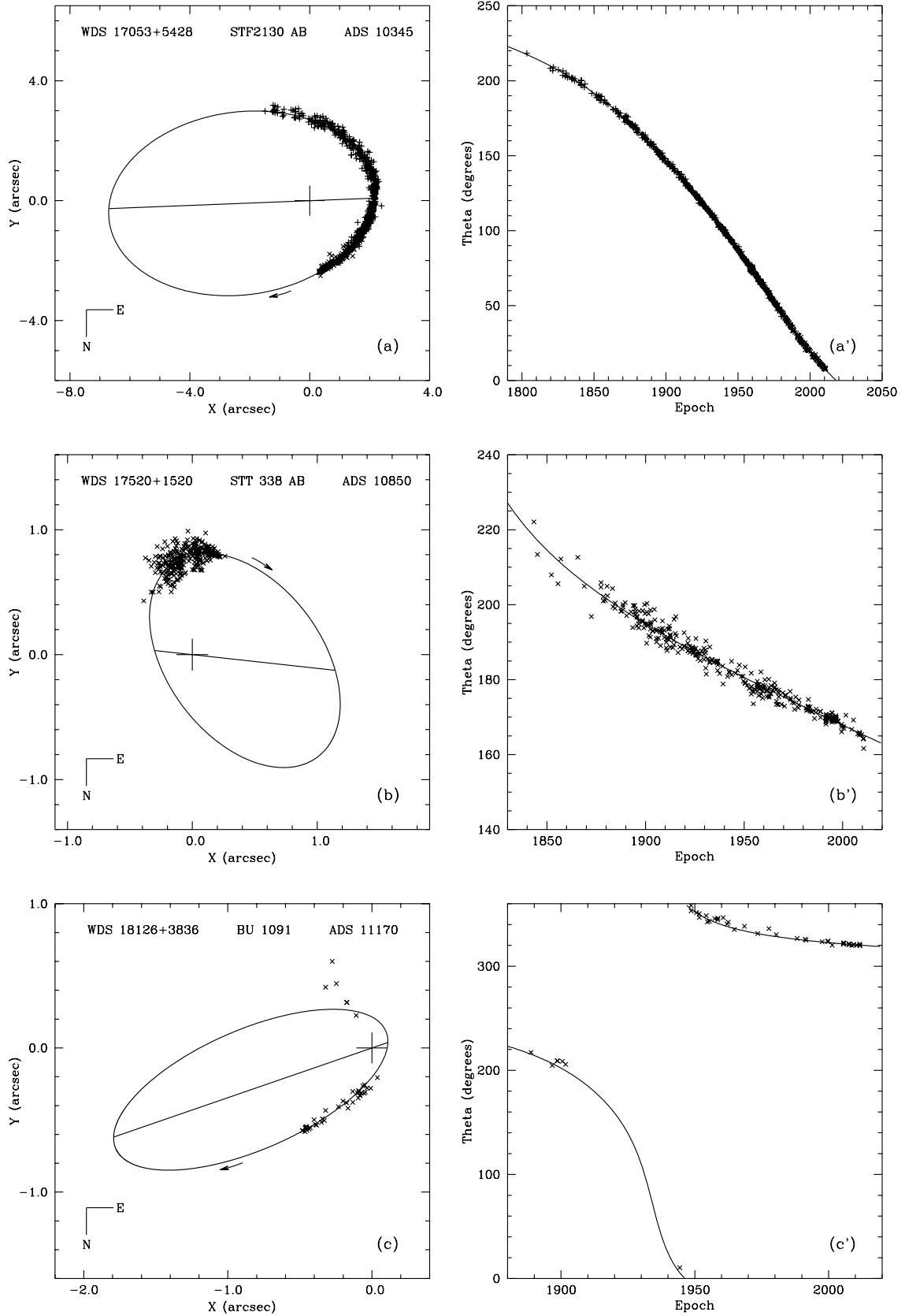
In Fig. 5a’,b’,c’ and 6a’,b’,c’ we have plotted the theta measurements (small crosses) and the corresponding values of our computed orbits (continuous lines, in green for the on-line edition). The new data obtained after the last publication are plotted as small  $\times$  (in red for the on-line edition) and the previous data as small  $+$  (in blue). The orbits of ADS 10850 and 11170 have been computed for the first time and all the plotted measurements can therefore be considered as new data. For the other objects, there are 8 new observations in 2005.942–2010.201 for ADS 5469, 17 new observations in 2007.290–2010.395 for ADS 8128, 5 new observations in 1998.392–2009.260 for ADS 8239, and 175 new observations in 1980.565–2010.865 for ADS 10345.

In Table 12, we present some physical parameters of those systems. The visual magnitudes (Col. 3), the difference of magnitude between the components (Col. 4) and the spectral types (Col. 5) were extracted from the IC4 and the SIMBAD data bases. The dynamical parallaxes are presented in Col. 6. Except for ADS 10850 (see in Sec. 4.5), those parallaxes 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 either the Hipparcos parallaxes from ESA (1997) or the revised values from van Leeuwen (2007a), as indicated in Col. 11. In Cols. 8, 9 and 10, we give the corresponding angular and linear sizes of  $a$  and  $\mathfrak{M}_{\text{total}}$ , respectively, that were computed from our orbital elements and the Hipparcos parallaxes.

Note that we found a small difference between the parallax values reported in van Leeuwen (2007a)’s paper and those printed in his book (van Leeuwen, 2007b). In this paper, we adopted the values from van Leeuwen (2007a) which correspond to his most recent results (van Leeuwen, private communication), and were selected by the SIMBAD data base.



**Figure 5.** New orbits of ADS 5469 (a), ADS 8128 (b) and ADS 8239 (c). The corresponding temporal variation of the position angles is plotted in (a'), (b') and (c'). Online-edition: the measurements obtained after the computation of the previous published orbits are plotted in red (see text).



**Figure 6.** New orbits of ADS 10345 (a), ADS 10850 (b) and ADS 11170 (c). The corresponding temporal variation of the position angles is plotted in (a'), (b') and (c'). Online-edition: the measurements obtained after the computation of the previous published orbits are plotted in red (see text).

**Table 4.** New orbital elements of ADS 5469, 8128, 8239, 10345, 10850, and 11170.

| ADS       | $\Omega_{2000}$<br>( $^{\circ}$ ) | $\omega$<br>( $^{\circ}$ ) | $i$<br>( $^{\circ}$ ) | $e$          | $T$<br>(yr) | $P$<br>(yr) | $n$<br>( $^{\circ}/\text{yr}$ ) | $a$<br>( $''$ ) | A<br>( $''$ ) | B<br>( $''$ ) | F<br>( $''$ ) | G<br>( $''$ ) |
|-----------|-----------------------------------|----------------------------|-----------------------|--------------|-------------|-------------|---------------------------------|-----------------|---------------|---------------|---------------|---------------|
| ADS 5469  | 106.3                             | 146.3                      | 41.3                  | 0.891        | 1935.683    | 349.21      | 1.0309                          | 1.06            | -0.17657      | -0.97044      | 0.80096       | -0.37855      |
|           | $\pm 20.3$                        | $\pm 19.3$                 | $\pm 27.9$            | $\pm 0.0428$ | $\pm 4.82$  | $\pm 180$   | $\pm 0.531$                     | $\pm 0.059$     |               |               |               |               |
| ADS 8128  | 184.30                            | 2.6                        | 53.9                  | 0.881        | 2010.223    | 551.4       | 0.6529                          | 2.624           | -2.60866      | -0.26648      | 0.23450       | -1.53119      |
|           | $\pm 1.42$                        | $\pm 6.0$                  | $\pm 2.5$             | $\pm 0.015$  | $\pm 0.194$ | $\pm 151$   | $\pm 0.179$                     | $\pm 0.037$     |               |               |               |               |
| ADS 8239  | 42.3                              | 327.1                      | 53.3                  | 0.748        | 1914.42     | 706.0       | 0.5099                          | 1.69            | 1.39998       | 0.54176       | 0.10759       | 1.22864       |
|           | $\pm 1.32$                        | $\pm 2.3$                  | $\pm 1.9$             | $\pm 0.046$  | $\pm 0.58$  | $\pm 191$   | $\pm 0.138$                     | $\pm 0.09$      |               |               |               |               |
| ADS 10345 | 282.85                            | 193.31                     | 142.2                 | 0.5139       | 1946.19     | 812.0       | 0.4434                          | 4.48            | -0.17482      | 4.42758       | 3.58503       | -0.23915      |
|           | $\pm 0.80$                        | $\pm 0.83$                 | $\pm 1.3$             | $\pm 0.029$  | $\pm 0.72$  | $\pm 70.5$  | $\pm 0.039$                     | $\pm 0.03$      |               |               |               |               |
| ADS 10850 | 28.2                              | 111.1                      | 124.2                 | 0.582        | 1799.9      | 1276.6      | 0.2820                          | 1.14            | -0.07946      | -0.72332      | -1.05000      | -0.30034      |
| ADS 11170 | 140.5                             | 41.7                       | 133.4                 | 0.884        | 1930.1      | 1460.0      | 0.2466                          | 1.15            | -0.32820      | 0.95175       | 0.96556       | -0.03138      |

**Table 5.** ADS 5469: O-C residuals of our new orbit (after 1990.0).

| Epoch    | $\Delta\rho$ (O-C)<br>( $''$ ) | $\Delta\theta$ (O-C)<br>( $^{\circ}$ ) | Observer |
|----------|--------------------------------|--|----------|
| 1991.093 | -0.06                          | -3.7                                   | WSI      |
| 1991.250 | 0.05                           | -0.5                                   | HIP      |
| 1991.820 | 0.05                           | -0.1                                   | TYC      |
| 1993.120 | -0.08                          | 3.3                                    | Hei      |
| 1995.120 | 0.06                           | 4.2                                    | Hei      |
| 1997.140 | 0.16                           | 2.7                                    | Hei      |
| 2005.942 | -0.00                          | 0.2                                    | Hor      |
| 2005.942 | -0.00                          | 0.2                                    | Hor      |
| 2007.012 | -0.01                          | -0.2                                   | Hor      |
| 2007.198 | -0.00 <sup>P</sup>             | -0.7 <sup>P</sup>                      | Pru      |
| 2007.826 | -0.00                          | 0.6                                    | Hor      |
| 2008.773 | -0.01                          | -0.7                                   | Tok      |
| 2009.262 | -0.02                          | -0.5                                   | Tok      |
| 2010.201 | -0.05 <sup>P</sup>             | -0.8 <sup>P</sup>                      | Sca      |

**Table 6.** ADS 8128: O-C residuals of our new orbit (after 2006.0).

| Epoch    | $\Delta\rho$ (O-C)<br>( $''$ ) | $\Delta\theta$ (O-C)<br>( $^{\circ}$ ) | Observer |
|----------|--------------------------------|--|----------|
| 2007.277 | -0.01 <sup>P</sup>             | 0.1 <sup>P</sup>                       | Pru      |
| 2007.288 | -0.02 <sup>P</sup>             | -0.3 <sup>P</sup>                      | Pru      |
| 2007.290 | 0.00                           | 2.7                                    | Alz      |
| 2007.311 | 0.01                           | 1.4                                    | Hrt      |
| 2009.207 | 0.01 <sup>P</sup>              | -0.2 <sup>P</sup>                      | Sca      |
| 2009.260 | 0.01                           | -0.2                                   | Tok      |
| 2009.265 | -0.00 <sup>P</sup>             | 1.1 <sup>P</sup>                       | Sca      |
| 2009.330 | 0.01 <sup>P</sup>              | 0.5 <sup>P</sup>                       | Sca      |
| 2009.349 | -0.01 <sup>P</sup>             | 0.8 <sup>P</sup>                       | Sca      |
| 2009.382 | 0.01 <sup>P</sup>              | 0.1 <sup>P</sup>                       | Sca      |
| 2009.385 | 0.01 <sup>P</sup>              | 0.2 <sup>P</sup>                       | Sca      |
| 2009.390 | 0.00 <sup>P</sup>              | -0.1 <sup>P</sup>                      | Sca      |
| 2009.396 | 0.01 <sup>P</sup>              | 0.3 <sup>P</sup>                       | Sca      |
| 2010.264 | -0.00 <sup>P</sup>             | -0.4 <sup>P</sup>                      | Sca      |
| 2010.300 | 0.01 <sup>P</sup>              | 0.2 <sup>P</sup>                       | Sca      |
| 2010.324 | 0.01 <sup>P</sup>              | 0.4 <sup>P</sup>                       | Sca      |
| 2010.327 | 0.01 <sup>P</sup>              | 1.0 <sup>P</sup>                       | Sca      |
| 2010.384 | 0.01 <sup>P</sup>              | -0.3 <sup>P</sup>                      | Sca      |
| 2010.395 | 0.01 <sup>P</sup>              | -1.6 <sup>P</sup>                      | Sca      |

**Table 7.** ADS 8239: O-C residuals of our new orbit (after 1990.0).

| Epoch    | $\Delta\rho$ (O-C)<br>( $''$ ) | $\Delta\theta$ (O-C)<br>( $^{\circ}$ ) | Observer |
|----------|--------------------------------|--|----------|
| 1991.250 | 0.04                           | -0.2                                   | HIP      |
| 1991.860 | 0.09                           | -1.1                                   | TYC      |
| 1996.160 | -0.04                          | -1.9                                   | Pri      |
| 1996.370 | 0.14                           | -3.0                                   | Hei      |
| 1998.392 | -0.15                          | 1.5                                    | WSI      |
| 2000.339 | -0.01                          | -0.4                                   | WSI      |
| 2001.327 | -0.04                          | 2.0                                    | WSI      |
| 2007.317 | -0.02                          | 1.4                                    | Hrt      |
| 2009.260 | 0.04                           | 0.7                                    | Tok      |

**Table 8.** ADS 10345: O-C residuals of our new orbit (after 2007.0). The symbol <sup>P</sup> indicates PISCO measurements.

| Epoch    | $\Delta\rho$ (O-C)<br>( $''$ ) | $\Delta\theta$ (O-C)<br>( $^{\circ}$ ) | Observer |
|----------|--------------------------------|--|----------|
| 2008.369 | -0.03                          | 0.1                                    | Ant      |
| 2008.383 | -0.02                          | -0.5                                   | Ant      |
| 2008.388 | 0.02                           | 0.4                                    | Ant      |
| 2008.458 | -0.15                          | 0.3                                    | WSI      |
| 2008.564 | 0.01 <sup>P</sup>              | 0.2 <sup>P</sup>                       | Sca      |
| 2008.859 | -0.03                          | 0.6                                    | Ary      |
| 2009.304 | -0.00                          | 0.5                                    | Ant      |
| 2009.448 | -0.02                          | -0.6                                   | Los      |
| 2009.541 | -0.00 <sup>P</sup>             | 0.1 <sup>P</sup>                       | Sca      |
| 2009.608 | 0.00                           | -0.2                                   | WSI      |
| 2009.872 | 0.13                           | 0.0                                    | Ary      |
| 2010.259 | -0.02                          | 0.0                                    | Los      |
| 2010.459 | -0.00                          | 0.0                                    | Ant      |
| 2010.538 | 0.00 <sup>P</sup>              | 0.2 <sup>P</sup>                       | Sca      |
| 2010.539 | -0.05                          | 0.3                                    | WSI      |
| 2010.723 | 0.00                           | 0.1                                    | Ant      |
| 2010.865 | -0.01                          | 1.4                                    | Ary      |

#### 4.1 New orbit of WDS 06487+0737 – A 2731 – ADS 5469

**ADS 5469, A 2731 (HIP 32650):** This couple was discovered in 1913 by Aitken with the 91-cm great refractor of Lick Observatory. In the years following this discovery, a significant motion was immediately suspected, but this ac-

**Table 9.** ADS 10850: O-C residuals of our new orbit (after 2000.0). The symbol  $P$  indicates PISCO measurements.

| Epoch    | $\Delta\rho$ (O-C)<br>( $''$ ) | $\Delta\theta$ (O-C)<br>( $^\circ$ ) | Observer |
|----------|--------------------------------|--------------------------------------|----------|
| 2000.489 | -0.00                          | -0.2                                 | Doc      |
| 2000.521 | -0.02                          | -0.7                                 | WSI      |
| 2001.610 | -0.03                          | 3.0                                  | Ary      |
| 2004.657 | -0.01 $P$                      | 0.0 $P$                              | Sca      |
| 2005.460 | -0.06                          | 2.7                                  | WSI      |
| 2007.655 | -0.00 $P$                      | -0.4 $P$                             | Sca      |
| 2008.473 | 0.02                           | 0.2                                  | Thr      |
| 2008.475 | 0.00                           | -0.5                                 | Thr      |
| 2008.659 | -0.01 $P$                      | -0.1 $P$                             | Sca      |
| 2009.615 | -0.02 $P$                      | -0.1 $P$                             | Sca      |
| 2010.459 | -0.02                          | -1.1                                 | Ant      |
| 2010.669 | -0.01 $P$                      | -0.9 $P$                             | Sca      |
| 2010.681 | -0.00                          | -3.6                                 | Ant      |

**Table 10.** ADS 11170: O-C residuals of our new orbit (after 2000.0). The symbol  $P$  indicates PISCO measurements.

| Epoch    | $\Delta\rho$ (O-C)<br>( $''$ ) | $\Delta\theta$ (O-C)<br>( $^\circ$ ) | Observer |
|----------|--------------------------------|--------------------------------------|----------|
| 2001.373 | 0.03                           | -2.2                                 | Mor      |
| 2005.550 | -0.01                          | 0.8                                  | Slm      |
| 2005.589 | -0.07                          | -0.4                                 | WSI      |
| 2005.708 | 0.00 $P$                       | 0.8 $P$                              | Sca      |
| 2007.611 | 0.01                           | 0.6                                  | Gii      |
| 2007.668 | -0.00 $P$                      | -0.5 $P$                             | Sca      |
| 2008.665 | -0.01 $P$                      | -0.9 $P$                             | Pru      |
| 2009.431 | -0.01                          | 0.1                                  | Orl      |
| 2009.442 | -0.01                          | 0.1                                  | Orl      |
| 2010.500 | -0.02                          | -0.2                                 | Los      |
| 2011.628 | -0.00 $P$                      | 1.0 $P$                              | Sca      |
| 2011.737 | 0.00 $P$                       | -0.5 $P$                             | Sca      |
| 2011.742 | 0.00 $P$                       | -0.3 $P$                             | Sca      |

tually came from a wrong measure reported between the two Aitken measures of 1913.97 and 1921.82 (see Muller, 1957). This error was soon discovered and the interest for this object disappeared. ADS 5469 was then neglected by the observers for the next two decades. In 1944, it was then a great surprise to discover the companion in the first quadrant, beyond the periastron, at about  $260^\circ$  from the position measured by Aitken. The available measures are then nearly exclusively located in the first quadrant. The only measurements of good quality obtained before the periastron passage (which occurred in 1935) are the two Aitken measures. As a result all the orbit calculations of ADS 5469 rely on the validity of those two observations. Three orbits have been published yet: Muller (1957), Docobo (1984) and Heintz (1998).

Heintz' orbit leads to rather large residuals in  $\rho$  ( $-0''.11$ ) with our measurement of 2010.201. The other measures made in the last years indicate the same trend. We also noticed that Heintz (1998) did not give any information on the errors and derived masses for this orbit. We thus decided to compute a new orbit with the 39 available observations.

Using the procedure described above, we obtained a

straightforward convergence, although the uncertainties on the elements are rather large (see Table 4).

The mean rms residuals are  $0''.066$  and  $1^\circ.841$  for  $\rho$  and  $\theta$ , respectively. The dynamic parallax is in good agreement with the Hipparcos measurement (especially with van Leeuwen's revised value) and the systemic mass is consistent with the theoretical expected value for a F8V+G3V system (see Table 12).

Note finally that in the literature, this object is also known as G 108-29, a high proper motion star, with a proper motion of  $-59.89 \pm 0.95$  mas/yr in right-ascension, and  $-376.61 \pm 0.75$  mas/yr in declination, according to Hipparcos (van Leeuwen, 2007a).

#### 4.2 New orbit of WDS 11190+1416 – STF 1527 – ADS 8128

**ADS 8128, STF 1527 (HIP 55254):** this couple was measured for the first time in 1822, by F.G.W. Struve in Dorpat with a Troughton meridian circle of 9.5 cm in diameter equipped since 1821 with an excellent filar micrometer built by J. Fraunhofer (Struve, 1827). It has been regularly observed since and 268 measurements are now available, if we add our six measurements made in 2010. However it should be mentioned that the 51 measurements made in the 19th century have a rather large scatter, especially in angular separation. It should be mentioned that 16 out of the 19 observations made after 2006 were obtained by our group (see Table 6).

The first orbit was computed by Hopmann (1960), who proposed a long period orbit ( $P = 1148$  yr). The next measurements suggested a shorter period.

Our new orbital elements reported in Table 4 well fit the observations (see Fig. 5b and 5b'), with mean rms errors of  $0''.16$  and  $1^\circ.5$  for the residuals in  $\rho$  and  $\theta$ , respectively. Compared to our previous orbit computed in 2008 (Paper VII), we have now a better constraint on the periastron epoch which occurred in the beginning of 2010. It seems that PISCO observations are the only ones that were made in that critical period. Although this orbit is still preliminary (grade 3–4) since only about half of it has been monitored yet, we do not think it will change much in the future.

The spectral type is F9V according to Harlan and Taylor (1970). The companion is probably of type G3V since  $\Delta m_V = 1.2$  (see Table 12). Using the Hipparcos parallax of ESA (1997), the total mass  $\mathcal{M}_{total} = 2.0 M_\odot$  is compatible with the theoretical values for a system of two stars of type F9V and G3V, and the dynamical parallax of 31.2 mas is in very good agreement with this Hipparcos measurement of 31.17 mas (see Table 12). The agreement is also good with the revised Hipparcos values published by van Leeuwen (2007a).

#### 4.3 New orbit of WDS 11368-1221 – BU 456 – ADS 8239

**ADS 8239, BU 456 (HIP 56641):** this couple was discovered by S.W. Burnham in 1877 in his own small backyard observatory in Chicago, using an excellent 15-cm aperture refractor built by Alvan Clark in 1870 (Burnham, 1877).

**Table 11.** New ephemerides of ADS 5469, 8128, 8239, 10345, 10850, and 11170.

| Epoch  | ADS 5469           |                          | ADS 8128           |                          | ADS 8239           |                          | ADS 10345          |                          | ADS 10850          |                          | ADS 11170          |                          |
|--------|--------------------|--------------------------|--------------------|--------------------------|--------------------|--------------------------|--------------------|--------------------------|--------------------|--------------------------|--------------------|--------------------------|
|        | $\rho$<br>( $''$ ) | $\theta$<br>( $^\circ$ ) | $\rho$<br>( $''$ ) | $\theta$<br>( $^\circ$ ) | $\rho$<br>( $''$ ) | $\theta$<br>( $^\circ$ ) | $\rho$<br>( $''$ ) | $\theta$<br>( $^\circ$ ) | $\rho$<br>( $''$ ) | $\theta$<br>( $^\circ$ ) | $\rho$<br>( $''$ ) | $\theta$<br>( $^\circ$ ) |
| 2012.0 | 1.354              | 65.6                     | 0.296              | 209.7                    | 1.123              | 160.4                    | 2.439              | 6.0                      | 0.831              | 164.9                    | 0.748              | 320.2                    |
| 2013.0 | 1.364              | 65.8                     | 0.286              | 224.6                    | 1.133              | 160.8                    | 2.457              | 5.0                      | 0.831              | 164.7                    | 0.754              | 320.0                    |
| 2014.0 | 1.373              | 66.0                     | 0.285              | 240.1                    | 1.142              | 161.3                    | 2.476              | 4.0                      | 0.831              | 164.4                    | 0.760              | 319.9                    |
| 2015.0 | 1.383              | 66.2                     | 0.295              | 255.1                    | 1.152              | 161.7                    | 2.495              | 3.0                      | 0.832              | 164.2                    | 0.767              | 319.7                    |
| 2016.0 | 1.393              | 66.4                     | 0.318              | 268.5                    | 1.162              | 162.1                    | 2.514              | 2.0                      | 0.832              | 163.9                    | 0.773              | 319.5                    |
| 2017.0 | 1.402              | 66.6                     | 0.351              | 279.8                    | 1.171              | 162.6                    | 2.533              | 1.1                      | 0.832              | 163.7                    | 0.779              | 319.3                    |
| 2018.0 | 1.411              | 66.8                     | 0.391              | 289.0                    | 1.181              | 163.0                    | 2.553              | 0.2                      | 0.833              | 163.4                    | 0.784              | 319.2                    |
| 2019.0 | 1.421              | 67.0                     | 0.435              | 296.4                    | 1.191              | 163.4                    | 2.573              | 359.3                    | 0.833              | 163.2                    | 0.790              | 319.0                    |
| 2020.0 | 1.430              | 67.2                     | 0.483              | 302.3                    | 1.200              | 163.8                    | 2.593              | 358.4                    | 0.833              | 163.0                    | 0.796              | 318.8                    |
| 2021.0 | 1.439              | 67.4                     | 0.532              | 307.2                    | 1.210              | 164.2                    | 2.614              | 357.5                    | 0.834              | 162.7                    | 0.802              | 318.7                    |

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

| Name      | HIP   | $m_V$ | $\Delta m_V$ | Spectral type | $\varpi_{\text{dyn}}$<br>(mas) | $\varpi_{\text{HIP}}$<br>(mas) | $a$<br>( $''$ ) | $a$<br>(AU) | $\mathfrak{M}_{\text{total}}$<br>( $M_\odot$ ) | Source of $\varpi_{\text{HIP}}$ |
|-----------|-------|-------|--------------|---------------|--------------------------------|--------------------------------|-----------------|-------------|--|---------------------------------|
| ADS 5469  | 32650 | 7.93  | 1.3          | F8V+G3V       | 17.1                           | 19.96                          | 1.06            | 53.1        | 1.2  | ESA (1997)                      |
| "         | "     | "     | "            |               |                                | $\pm 1.57$                     | $\pm 0.06$      | $\pm 5.1$   | $\pm 1.3$                                      | van Leeuwen (2007a)             |
|           |       |       |              |               |                                | 18.82                          |                 | 56.3        | 1.5  |                                 |
|           |       |       |              |               |                                | $\pm 1.00$                     |                 | $\pm 4.3$   | $\pm 1.6$                                      |                                 |
| ADS 8128  | 55254 | 6.95  | 1.2          | F9V           | 31.2                           | 31.17                          | 2.62            | 84.2        | 2.0  | ESA (1997)                      |
| "         | "     | "     | "            |               |                                | $\pm 1.55$                     | $\pm 0.04$      | $\pm 4.4$   | $\pm 1.1$                                      | van Leeuwen (2007a)             |
|           |       |       |              |               |                                | 32.53                          |                 | 80.7        | 1.7  |                                 |
|           |       |       |              |               |                                | $\pm 1.39$                     |                 | $\pm 3.6$   | $\pm 1.0$                                      |                                 |
| ADS 8239  | 56641 | 8.97  | 0.2          | G5            | 18.6                           | 20.45                          | 1.69            | 82.6        | 1.1  | ESA (1997)                      |
| "         | "     | "     | "            |               |                                | $\pm 2.88$                     | $\pm 0.09$      | $\pm 12.4$  | $\pm 0.8$                                      | van Leeuwen (2007a)             |
|           |       |       |              |               |                                | 20.75                          |                 | 81.5        | 1.1  |                                 |
|           |       |       |              |               |                                | $\pm 1.44$                     |                 | $\pm 7.1$   | $\pm 0.7$                                      |                                 |
| ADS 10345 | 83608 | 5.80  | 0.03         | F5V           | 36.3                           | 37.08                          | 4.48            | 120.7       | 2.7  | ESA (1997)                      |
| "         | "     | "     | "            |               |                                | $\pm 0.89$                     | $\pm 0.03$      | $\pm 3.0$   | $\pm 0.5$                                      | van Leeuwen (2007a)             |
|           |       |       |              |               |                                | 36.45                          |                 | 122.8       | 2.8  |                                 |
|           |       |       |              |               |                                | $\pm 0.46$                     |                 | $\pm 1.8$   | $\pm 0.5$                                      |                                 |
| ADS 10850 | 87427 | 6.42  | 0.3          | K0III         | 7.9                            | 7.40                           | 1.14            | 154.        | 2.2  | ESA (1997)                      |
| "         | "     | "     | "            |               |                                | $\pm 2.0$                      |                 | $\pm 42.$   | $\pm 1.8$                                      | van Leeuwen (2007a)             |
|           |       |       |              |               |                                | 4.27                           |                 | 267.        | 12.  |                                 |
|           |       |       |              |               |                                | $\pm 1.31$                     |                 | $\pm 82.$   | $\pm 11.$                                      |                                 |
| ADS 11170 | 89237 | 8.19  | 0.6          | F8V           | 6.0                            | 5.77                           | 1.15            | 199.        | 3.7  | ESA (1997)                      |
| "         | "     | "     | "            |               |                                | $\pm 1.24$                     |                 | $\pm 43.$   | $\pm 2.4$                                      | van Leeuwen (2007a)             |
|           |       |       |              |               |                                | 6.85                           |                 | 168.        | 2.2  |                                 |
|           |       |       |              |               |                                | $\pm 0.93$                     |                 | $\pm 23.$   | $\pm 0.9$                                      |                                 |

This instrument had no micrometer and the first measure was soon done by A. Hall with the 66-cm aperture Clark refractor of the U.S. Naval Observatory. This couple has been regularly observed since, but its declination of  $-12^\circ$  makes it difficult to observe from Merate.

The first orbit was calculated by Zagar (1933), and then followed successively by the orbits of Abrami (1954), Scardia (1982), Baize (1991) and Olevic & Popovic (2000). The most recent orbit of Olevic & Popovic (2000) begins to show systematic errors in separation, whereas our orbit of Scardia (1982) is still valid and leads to smaller residuals. Nevertheless we decided to take advantage of about 30 years of observations to revise our orbit of 1982.

Using the 74 available measurements we obtained the elements reported in Table 4. The corresponding standard

deviations of the residuals are  $2^\circ.2$  and  $0''.06$  for  $\theta$  and  $\rho$ , respectively. This new orbit is still provisory, with a large uncertainty on the period, because the orbit has only been monitored close to the periastron.

The small magnitude difference of  $\Delta m_V = 0.2$  suggests a companion of G-K spectral type. The sum of the masses computed using the Hipparcos parallax of  $1.1 M_\odot$  is smaller than the theoretical values, but is compatible with theoretical values when taking into account its large uncertainties of 60%. The dynamical parallax obtained with Baize-Romani (1946)'s method is in fair agreement with Hipparcos measurement. The total dynamic systemic mass is slightly small, which was already noticed by Baize with his own determination and he suggested a spectral type later than K for both components.

#### 4.4 New orbit of WDS 17053+5428 – STF 2130 – ADS 10345

**ADS 10345, STF 2130 (HIP 83608):** this well-known couple was discovered in 1779 by W. Herschel and then classified as H II 13. W. Herschel found a relative motion of the two components in 1804, but clearly established its orbital motion only in 1821. J. Herschel and J. South (1824) made other observations of this binary star and reported them with “...No doubt therefore can remain of the reality of an angular motion in this star, as announced by Sir William Herschel in 1804...”. F.G.W. Struve observed this couple for the first time in 1819 at the Dorpat Observatory (Struve, 1827), with a Troughton meridian circle of 9.5 cm in diameter. He observed it again in 1828, with the 25 cm aperture Fraunhofer refractor and classified it with the number 2130 in his catalogue. From that time this couple has been systematically measured by numerous observers first visually with a micrometer, then, after 1949, with long focal photography, and finally since 1976 with speckle interferometry. Many orbits have been calculated for ADS 10345. The orbit of Scardia (1980) does not represent the observations any longer, showing a systematic discrepancy both in separation and in position angle, indicating that the period and the semi major axis were underestimated. Heintz’ orbit (1981) computed at the same epoch has a much longer period and semi major axis. This orbit is in better agreement with the latest observations, but now leads to systematic residuals.

Taking advantage of the good quality measurements obtained since our last determination of 1980, we computed the new orbital elements presented in Table 4 with the 766 available measurements. The mean rms residuals are  $0''.08$  and  $0^\circ.9$ , for  $\rho$  and  $\theta$ , respectively. The uncertainties on the orbital elements are small, if we except the period, which is poorly known because the orbit has been monitored yet only close to the periastron (see Fig. 6a). The true orbital period must be very long, likely in the range 700–900 years.

Its spectral type is F5V according to SIMBAD data base. The very small magnitude difference  $\Delta m_V = 0.03$  (see Table 12) indicates that the two components have the same spectral classification. The systemic mass of  $2.7 M_\odot$  derived from our orbital elements and Hipparcos parallax is in very good agreement with the expected value for two F5V stars, which is  $2.8 M_\odot$  according to Drilling & Landolt (1999). Similarly, the dynamic parallax of 36.3 mas well agrees with the parallax measured by Hipparcos (see Table 12). Note that the B component is itself a spectroscopic binary ( $P = 2270$  days,  $V_0 = -16.6$  km/s).

#### 4.5 New orbit of WDS 17520+1520 – STT 338AB – ADS 10850

**ADS 10850, STT 338AB (HIP 87427):** this couple was discovered by O. Struve between August 26th 1841 and December 7th 1842 with the 38 cm Merz-Mahler refractor of Pulkova Central Observatory (Struve, 1843). The first measure was made by Maedler with the 25 cm refractor of Dorpat Observatory, on April 25th 1843 (Maedler, 1845).

The observations are numerous with 314 measures available for  $\theta$  and 300 measures for  $\rho$ , but the old data are scattered both for  $\theta$  and  $\rho$ . Our orbit is the first ever computed for this object. For this computation, we took advantage of

the 8 measures obtained by our group since 1998 (which represents 50% of the total measures reported in the WDS after 1998). The orbital elements presented in Table 4 were obtained using Kowalsky’s method. The mean rms error was  $0''.069$  and  $1^\circ.927$  for  $\rho$  and  $\theta$ , respectively. It is still preliminary (i.e., grade 4 orbit) because the orbital period is long and the arc of orbit covered by the observations is short (see Fig. 6b).

The spectral type is K0III from SIMBAD data base. The small magnitude difference indicates that the two components have a similar spectral type. The systemic mass of  $2.3 M_\odot$  obtained with the parallax measured by Hipparcos (ESA, 1997), is in very good agreement with the theoretical value of  $2.2 M_\odot$  expected for a system of two K0III stars (Drilling & Landolt, 1999). As our orbit is only preliminary, this can be considered as very satisfactory. Conversely, the value of  $12 M_\odot$  obtained with the revised parallax of van Leeuwen (2007a) is much too large.

Since the primary star is a giant star, the dynamical parallax cannot be computed with Baize-Romani’s method which is based on the mass-luminosity relation. So we derived it in Table 12 from Kepler’s third law:

$$\varpi_{\text{dyn}} = \frac{a}{(\mathfrak{M}_1 + \mathfrak{M}_2)^{1/3} P^{2/3}}$$

where  $\mathfrak{M}_1$  and  $\mathfrak{M}_2$  are the component masses in  $M_\odot$ ,  $P$  the period in years, and  $a$  the semi major axis in arcseconds. Assuming similar masses for the two components of  $1.1 M_\odot$ , we obtained  $\varpi_{\text{dyn}} = 7.9$  mas. This value is in good agreement with the Hipparcos parallax from ESA (1997), but in disagreement with van Leeuwen (2007a) revised values.

#### 4.6 New orbit of WDS 18126+3836 – BU 1091 – ADS 11170

**ADS 11170, BU 1091 (HIP 89237):** this couple was discovered by S.W. Burnham on October 20th 1888 (Burnham, 1890) at the Lick Observatory with the excellent 30 cm refractor built by Alvan Clark and installed on Mount Hamilton in 1881.

Our new orbit was computed using our measures made in 2007, 2008 (see Table 10) and in 2011 (three measures not yet published), and the other measures available in the USNO data base. This led to a total number of 45 measures.

The observations of ADS 11170 made before 1920, were reported in the first quadrant, and are spread out both in  $\rho$  and  $\theta$ . They would indicate a strange trajectory, in complete disagreement with the measures made after 1940 and for which the validity of the quadrant is well established (see the IC4 catalogue). We therefore assumed that this was an error, and moved those old observations from the first to the third quadrant. In this way, it was possible to compute a preliminary orbit with a long period and high eccentricity.

The spectral type is F8V according to SIMBAD. The magnitude difference suggests that the companion spectral type is about G5V. Hence the systemic mass is expected to be  $2 M_\odot$ . This is very close to what we obtained with the Hipparcos parallax revised by van Leeuwen (2007a), and still compatible with the value obtained with ESA (1997), when taking the uncertainties into account (see Table 12). The dynamical parallax derived with Baize-Romani (1946)’s method is in good agreement with the two values given for

the Hipparcos parallax in ESA (1997) and van Leeuwen (2007a).

## 5 CONCLUSION

In 2010, we obtained 207 new measurements of 191 visual binaries with PISCO in Merate, with an average accuracy of  $0''.01$  for the angular separation and  $0''.6$  for the position angles. The total number of measurements made in Merate since 2004 now exceeds 2300. This work is thus a good contribution to the continuing monitoring of long period visual binary systems, which is important for refining systemic stellar masses.

We then presented new orbital elements computed for ADS 5469, 8128, 8239, 10345, 10850 and 11170. The periastron passage of ADS 8128 occurred in 2010 and to our knowledge, our six measurements are the only ones made in 2010. This shows the importance of our observations made in this critical part of the orbit. They now provide a good constraint on the orbit of this binary star. The next periastron passage should occur in more than five hundred years!

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