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Astronomy
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CCD photometry and astrometry for visual double and multiple stars of the HIPPARCOS catalogue*

III. CCD photometry and differential astrometry for 253 southern "intermediate" systems

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Abstract. We present new astrometric and photometric data for 253 visual double stars of the "intermediate" class, i.e. with angular separations in the range 1 to 15 arcsec. The multi-colour observations were obtained in 1992–94 as part of the ESO Key Programme "Visual Double Stars" performed at La Silla Observatory (Chile). Differential magnitudes and colours have been secured in a systematic way while component magnitudes and colour indices have been determined in the V and I passbands of the Cousins standard system in good photometric conditions only. Internal and mean external errors are smaller than respectively 0.01 mag and a few hundreths of a magnitude (typically less than 0.03 mag). Relative positions are obtained as a by-product with internal errors of the order of $0.006''$ in angular separation (corresponding to pixel width $\times 0.02$) and 0.07° in position angle. Final accuracies are thoroughly discussed: we illustrate the overall excellent quality of the data and estimate the quality degradation for angular separations barely larger than the width of the seeing disk.

Key words. techniques: photometric – astrometry – stars: imaging – stars: binaries: visual – stars: fundamental parameters

1. Introduction

Starting in August 1990 a European Network of Laboratories "Visual Double Stars" was founded for combining the efforts of scientists in six European countries with the goal to obtain accurate ground-based photometric and astrometric data on visual double and multiple stars as a complement to the HIPPARCOS space observations (Oblak et al. 1992). In 1992 a key programme was introduced at the European Southern Observatory (ESO) aiming at obtaining the photometry and the astrometry of visual double stars in the southern hemisphere: photoelectric and CCD photometry would be carried out. A full scientific and technical description of this large scale project can be found in Oblak et al. (1999, Paper I). Cuypers & Seggewiss (1999, Paper II) report on the results of the two campaigns that immediately preceded the key programme observations. In this paper (Paper III) we report on the final results of five campaigns of the ESO key programme. Preliminary results of the combined data sets on the one hand and external comparisons with HIPPARCOS data on the other hand have already been presented on several occasions (Lampens et al. 1997; Oblak et al. 1997).

2. Observations

All our observations were obtained with a CCD camera attached to the 91 cm Dutch light collector at ESO La Silla (Chile). The data presented here concern double stars mostly, acquired during the campaigns of Aug. 13–17 1992 (PL), Nov. 10–15 1992 (EO), Dec. 23–28 1993 (PL), Aug. 17–21 1994 (PL) and Nov. 11–15 1994 (EO). In these runs we used the coated GEC CCD chips ESO #7, #29 and #33. The basic CCD characteristics are listed in Paper I. With the given focal distance of 12.51 m, theoretical scale values correspond to 0.363 arcsec pixel^{-1} (chip #7) and 0.445 arcsec pixel^{-1} (chips #29 and #33). In agreement with the network protocol (Paper I), we choose from the standard filter set a Bessel V (ESO #420)

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and a Gunn i (ESO #465) filter, supplemented by neutral density filters when needed. It was necessary to carefully monitor the focus throughout the night because of a systematic drift and a rapid focus degradation. This resulted in an acquisition rate much lower than expected. A precise determination of the difference in focus position between the filters V and i at the Dutch telescope (due to different thicknesses of the glasses) was thus obtained and applied once the focus was adjusted in any of the used filters. This allowed to observe with the highest possible angular resolution in each filter. In general the seeing in the filter i was slightly smaller than the one in the V filter. The total number of observations presented here consists of 253 observations of 239 Hipparcos programme stars, 14 observations of 12 "astrometric standards", more than one hundred observations of some 80 different photometric standard stars over 15 nights (as well as one observation of ADS 6223 and SAO 244567 each). In the mean, about 8 standard stars have been observed each night whenever it was possible, with extreme conditions varying between 5 and 11. Consult also Paper I for a general presentation of our programme.

3. Reduction and calibrations

All details on the common protocol, the preparatory work on the frames as well as a description of the used reduction procedures can be found in Paper I. The reduction method, developed and discussed by Cuypers (1997), is specifically adapted to double-star imaging. The reason for a dedicated method is the regular absence of a single well-exposed point-spread function (PSF) reference star on the frames and the fact that the profiles of the components overlap when their separation is small. We first determined the background by taking the median of three of the four corner values of each frame. After sky subtraction, a generalized and unique Moffat PSF was fit to all the components simultaneously. A set of calibrator stars or "astrometric standards" has been regularly observed. These data together with the trails of bright objects are used to determine preliminary estimates of the scale and orientation values. In addition, these regularly observed astrometric standard stars allow valuable consistency tests for both the astrometry and the photometry (cf. Sect. 6). The final calibration of the scale and the orientation per CCD and per mission has been achieved at the level of 0.01% in scale and 0.07° in orientation by a careful comparison with the Hipparcos results (Oblak et al. 1997). An independent way of obtaining such accurate scale and orientation values (i.e. seeing independent as opposite to the method of the trailed images) consists in using astrometric standard fields located in well-studied but dense (open) clusters (e.g. Le Campion et al. 1996).

The transformation coefficients are listed together with the extinction coefficients for each night of "reasonable" photometric quality in Table 1. The tabulated coefficients were computed by fitting the following models using a classical least squares method:

Model 1 (with a non-linear colour dependence, bracketted in Table 1 and mainly significant in the filter V):

$$\begin{aligned}\mathrm{mag}_{i,\mathrm{st}} = \; & \mathrm{mag}_{i,\mathrm{obs}} + k_{i,1}.F_z + k_{i,2}.(V-I) \\ & + k_{i,3}.(V-I)^2 + C,\end{aligned}$$

where $k_{i,1}$ is the extinction for the filter i, $k_{i,2}$ and $k_{i,3}$ the colour terms, F_z the airmass, $(V-I)$ the (known) standard colour index and C the offset in magnitude;
Model 3 (where two or more nights were treated together):

$$\mathrm{mag}_{i,j,\mathrm{st}} = \mathrm{mag}_{i,\mathrm{obs}} + k_{i,j,1}.F_z + k_{i,2}.(V-I) + C,$$

where $k_{i,j,1}$ is the extinction for the filter i and for the night j while $k_{i,2}$ is the (unique) colour term;
Model 5 (where two or more nights were treated together and a non-linear colour dependence was applied):

$$\begin{aligned}\mathrm{mag}_{i,j,\mathrm{st}} &= \mathrm{mag}_{i,\mathrm{obs}} + k_{i,j,1}.F_z + k_{i,2}.(V-I) + C, \\ & \qquad \text{for} \quad (V-I) < 0.7 \\ \mathrm{mag}_{i,j,\mathrm{st}} &= \mathrm{mag}_{i,\mathrm{obs}} + k_{i,j,1}.F_z + k_{i,3}.(V-I) + C, \\ & \qquad \text{for} \quad (V-I) \geq 0.7\end{aligned}$$

where $k_{i,j,1}$ is the extinction for the filter i and for the night j while $k_{i,2}$ and $k_{i,3}$ are the two colour terms. In all these previous equations "mag" stands for both magnitudes V,st and I,st.

Models 3 and 5 were used when not enough standard stars in a single night had been measured or when the photometric quality during a small portion of a night was not guaranteed due to passing clouds, thereby allowing the transformation of a larger amount of differential data (thus defining the term *reasonable* photometric conditions). In these cases the transformation errors were assumed to be at least twice as large as computed from the fit. In the mean external errors as deduced from the residuals of the standard star data are seldomly larger than 0.03 mag. Such errors must be considered as safe upper limits. These values imply conditions which were not of the same (excellent) quality as the 1991–92 runs by Cuypers & Seggewiss (1999) as they obtained lower external errors of at most 0.02 mag (Paper II). One should mention that due to the secular effects of the Pinatubo eruption in 1991 the extinction coefficients are much larger than usual. In fact one may easily follow the evolution with time in the listed values of Table 1, where a decrease with a factor of two can be seen between the value for the extinction in August 92 and the one of November 94. From the measurements obtained in the Geneva photometric system a mean extinction value in V of 0.147 ± 0.014 can be deduced, in very good agreement with the values for December 93 found in Table 1.

A problem has however been detected while modelizing the transformation equations for the December 93 mission: inspection shows an anomaly in the sense that $k_i \simeq k_V$ and that the colour term is large. But the inclusion of an additional colour term allowed to obtain a good fit on the standard values and to take the effect of a probable

Table 1. Extinction and transformation coefficients.

Mission	Date [ddmm]	Filter	Neutral Filter?	Number of standards	Extinction Coeff.	Error	Transform. Coeff.	Error	Colour Term1	Error	Colour Term2	Error	Model Number
Aug. 92	1308	V	Y	5	0.244		–15.596		–0.100		(–0.1111)		1
		I		5	0.151		–17.107		0.000		(0.0000)		1
	1408	V	N	4	0.210		–20.606		–0.099		(–0.1099)		1
		I		4	0.160		–20.302		0.000		(0.0000)		1
	1508	V	N	9	0.269		–20606		–0.144		(–0.1648)		1
		I		9	0.217		–20.302		–0.018		(–0.0206)		1
	1608	V	N	9	0.225		–20.612		–0.099		(–0.1131)		1
		I		9	0.131		–20.255		0.026		(0.0297)		1
	1708	V	N	11	0.222		–20.620		–0.099		(–0.1131)		1
		I		11	0.157		–20.309		0.026		(0.0297)		1
Nov. 92	1311	V	N	5	0.168	0.021	–20.535	0.028	–0.0143	0.014			3
		I		6	0.118	0.014	–20.284	0.018	0.004	0.010			3
	1411	V	N	0	0.169	-	–20.535	-	–0.0143	-	(–0.1676)		-
		I		0	0.116	-	–20.284	-	0.004	-	(0.0047)		-
	1511	V	N	7	0.169	0.021	–20.535	0.028	–0.143	0.014			3
		I		8	0.115	0.013	–20.284	0.018	0.004	0.010			3
Dec. 93	2312	V	N	5	0.149	0.019	–22.152	0.022	–0.035	0.015	–0.042	0.008	5
		I		5	0.141	0.056	–22.999	0.062	0.853	0.044	0.404	0.027	5
	2412	V	N	5	0.136	0.015	–22.152	0.022	–0.035	0.015	–0.042	0.008	5
		I		5	0.107	0.043	–22.999	0.062	0.853	0.044	0.404	0.027	5
	2512	V	Y	8	0.151	0.022	–19.589	0.028	–0.079	0.019	0.003	0.034	5
		I		8	0.119	0.026	–20.834	0.035	0.481	0.022	0.308	0.041	5
	2612	V	Y	8	0.135	0.019	–19.589	0.028	–0.079	0.019	0.003	0.034	5
		I		8	0.119	0.024	–20.834	0.035	0.481	0.022	0.308	0.041	5
	2712	V	Y	8	0.139	0.019	–19.589	0.028	–0.079	0.019	0.003	0.034	5
		I		8	0.135	0.024	–20.834	0.035	0.081	0.022	0.308	0.041	5
Nov. 94	1211	V	N	5	0.174		–19.756		–0.020		(–0.0222)		1
		I		5	0.076		–19.716		0.081		(0.0901)		1
	1311	V	Y	8	0.121	0.044	–17.020	0.058	0.058	0.014			3
		I		7	0.041	0.036	–17.146	0.050	0.053	0.013			3
	1411	V	Y	8	0.153	0.046	–17.020	0.058	–0.058	0.014			3
		I		7	0.060	0.038	–17.146	0.050	0.053	0.013			3

filter mismatch into consideration. No systematic differences appeared between these measurements and the ones obtained during the rest of the campaigns. Although regularly measured and adopted as a secondary standard star (Clausen et al. 1997 give $\sigma_V = 0.006$ mag), we found on one occasion, during a night of good photometric stability, a possible variation at the level of a few hundreths of a magnitude in the V measurements of HD 7040 as shown in Table 2. The close proximity and faintness of a newly detected companion at a separation of $\sim 3.3''$ (cf. Table 3) is here certainly not in cause.

Table 2. Note on the magnitudes of HD 7040 in the Harvard region E105 (with standard values $V = 9.451$ mag and $I = 8.998$ mag).

Mission	Date	Filter	Airmass	Observed	Residual
Nov. 92	1511	V	1.041	9.492	0.041
	1511	I	1.038	9.021	0.023
Nov. 94	1211	V	1.046	9.469	–0.018
	1211	I	1.045	9.004	–0.006
Nov. 94	1411	V	1.051	9.361	–0.090
	1411	I	1.054	8.949	–0.049

4. Presentation of relative astrometry data

Table 3 lists the relative astrometry and differential photometry for 239 Hipparcos double stars, one apparently double (ADS 6223), one triple system (SAO 244567) and 12 astrometric standard stars. In the first column we list the identifier: generally a running Hipparcos number or, in a single case, a double star identifier. If no Hipparcos number exists, they are identified by their HD or Durchmusterung designation. Astrometric standard stars with an Hipparcos identifier are filed among the programme stars but can easily be recognized by the suffix "a" attached to the identifier. In the following columns, from left to right, we give the number of different observations, $N_{\rm obs}$, the component identification (Cp), the total number of frames, N, the mean separation (mean of two filters) with its standard deviation, the mean position angle (mean of two filters) with its standard deviation, the *instrumental* magnitude differences in V and i (with standard deviations), the Bessel epoch and a two letter code for the observer. Hereafter, both angular separation and

Table 3. CCD astrometry and differential photometry for 239 Hipparcos and 14 astrometric standard double stars.

Ident.	$N_{\rm obs}$	Cp	N	ρ_{V+I} (″)	σ_ρ (″)	θ_{V+I} (°)	σ_θ (°)	N_V	δm_V (mag)	$\sigma_{\delta m_V}$ (mag)	N_I	δm_I (mag)	$\sigma_{\delta m_I}$ (mag)	Date (year)	Obs.	$d_{\rm H}$ (″)
000045	1	B	14	2.837	0.005	242.60	0.08	7	1.982	0.010	7	1.504	0.009	92.6304	PL	0.017
000169	1	B	12	4.216	0.002	125.54	0.02	6	1.329	0.002	6	1.034	0.002	92.6276	PL	0.036
000248a	1	B	8	33.752	0.019	181.62	0.02	5	1.075	0.004	3	1.016	0.011	93.9818	PL	-
000645	1	B	8	9.671	0.002	289.65	0.01	5	0.015	0.003	3	-0.027	0.002	94.8637	EO	0.016
000924	2	B	26	6.584	0.001	303.04	0.01	19	1.829	0.024	7	1.396	0.001	92.6249	PL	0.025
001186	1	B	4	4.395	0.013	21.84	0.03	3	1.155	0.020	1	1.097	-	92.6305	PL	0.057
002438	2	B	21	11.233	0.003	359.28	0.01	7	2.928	0.011	14	2.418	0.001	94.8583	EO/PL	0.025
002449	1	B	4	3.570	0.004	275.37	0.03	2	0.479	0.003	2	0.560	0.002	94.8584	EO	0.017
002483	1	B	5	5.754	0.005	120.17	0.07	3	2.471	0.003	2	2.197	0.004	92.8707	EO	0.006
002663	1	B	20	4.727	0.001	169.49	0.01	10	1.920	0.001	10	1.683	0.002	94.8720	EO	0.056
003200	1	B	9	5.857	0.001	266.17	0.01	5	1.270	0.002	4	1.181	0.001	92.6277	PL	0.020
003205	1	B	4	4.303	0.003	248.00	0.02	3	0.218	0.001	1	0.271	-	92.6277	PL	0.020
003397	1	B	21	14.219	0.004	312.70	0.03	11	3.637	0.004	10	3.974	0.002	92.6196	PL	0.016
003827	1	B	5	8.540	0.002	291.30	0.01	2	0.408	0.002	3	0.383	0.001	92.6249	PL	0.036
004149	1	B	7	5.890	0.003	70.39	0.04	2	0.482	0.004	5	0.478	0.004	94.8639	EO	0.018
004404	1	B	27	3.536	0.011	273.98	0.10	13	3.255	0.009	14	2.789	0.011	92.6250	PL	0.149
004764	1	B	6	1.831	0.013	344.81	0.34	3	1.335	0.242	3	1.209	0.162	93.9819	PL	0.011
005413	1	B	26	4.371	0.003	39.10	0.05	13	2.226	0.004	13	2.146	0.004	93.9819	PL	0.010
005843a	2	B	58	13.980	0.005	56.50	0.02	31	4.280	0.033	25	5.438	0.137	92.6279	PL/EO	-
005992	1	B	13	2.445	0.006	330.58	0.06	6	1.827	0.013	7	1.434	0.007	94.8721	EO	0.020
006132	1	B	23	4.848	0.002	229.00	0.01	11	1.935	0.001	12	1.764	0.002	92.6278	PL	-
006707	1	B	13	7.189	0.005	233.76	0.03	11	1.366	0.004	2	1.260	0.004	92.8734	EO	0.018
007024	1	B	8	4.074	0.002	249.54	0.02	4	1.777	0.004	4	1.500	0.002	92.8708	EO	0.009
HD7040	1	B	2	3.258	0.144	302.78	0.42	0	-	-	2	4.633	0.131	94.8723	EO	-
007290	2	B	10	2.554	0.010	337.80	0.16	5	2.678	0.024	5	1.580	0.007	92.6278	PL	0.089
008054	1	B	9	5.573	0.002	293.92	0.04	8	1.441	0.007	1	1.307	-	92.8681	EO	0.036
008149	1	B	18	3.459	0.010	111.66	0.08	9	2.619	0.015	9	2.339	0.014	94.8641	EO	0.028
008236	1	B	8	6.295	0.001	348.23	0.02	4	2.739	0.002	4	2.419	0.001	92.6251	PL	-
008957	1	B	6	2.444	0.004	73.52	0.24	3	0.089	0.001	3	0.069	0.009	93.9845	PL	0.031
008965	1	B	6	1.370	0.020	343.44	0.69	3	1.826	0.117	3	1.590	0.166	93.9845	PL	0.025
009258	2	B	10	8.577	0.002	302.67	0.01	6	0.424	0.003	4	0.267	0.004	94.8722	PL/EO	0.024
009344	1	B	6	8.890	0.003	156.70	0.01	3	0.205	0.003	3	0.188	0.001	92.6251	PL	0.042
009651	1	B	6	7.385	0.002	269.15	0.02	3	0.211	0.000	3	0.153	0.002	92.6251	PL	0.074
010579	1	B	9	6.749	0.002	288.68	0.01	5	0.471	0.003	4	0.390	0.001	94.8585	EO	0.026
010683	1	B	4	2.499	0.006	199.39	0.04	2	0.808	0.004	2	0.776	0.009	92.8681	EO	0.003
010722	1	B	8	1.518	0.041	273.58	2.06	4	2.121	0.194	4	2.606	0.139	93.9846	PL	0.111
010983	1	B	22	1.703	0.024	335.79	0.38	9	3.192	0.137	13	3.595	0.110	94.8668	EO	0.240
011024	1	B	15	10.289	0.009	80.66	0.04	6	2.468	0.007	9	2.010	0.007	92.8708	EO	0.051
011219	1	B	10	5.209	0.002	115.52	0.02	10	1.265	0.003	0	-	-	94.8587	EO	0.014
011257	1	B	8	7.716	0.001	267.20	0.02	3	0.233	0.002	5	0.219	0.004	94.8585	EO	0.017
011945	1	B	5	3.637	0.003	346.04	0.03	3	0.103	0.005	2	0.117	0.011	93.9873	PL	0.022
012105	1	B	10	14.769	0.004	97.90	0.01	6	1.881	0.004	4	2.524	0.006	94.8587	EO	0.022
012708	1	B	7	2.144	0.007	43.29	0.45	3	0.269	0.023	4	0.251	0.014	93.9846	PL	0.083
012752	1	B	8	1.981	0.015	39.78	0.20	5	1.103	0.025	3	1.058	0.012	92.8683	EO	0.064
013199	1	B	6	5.646	0.004	193.94	0.02	4	0.364	0.003	2	0.390	0.004	93.9873	PL	0.010
013243	1	B	11	1.618	0.005	114.18	0.34	5	0.117	0.012	6	0.081	0.033	93.9792	PL	0.046
013815	1	B	25	1.699	0.030	42.94	1.80	12	2.393	0.083	13	2.382	0.061	93.9847	PL	0.483
013866	1	B	10	2.246	0.004	328.17	0.13	6	1.672	0.006	4	1.493	0.005	94.8587	EO	0.062
014584	1	B	12	8.588	0.002	295.65	0.01	12	1.107	0.001	0	-	-	93.9819	PL	0.014
015118	1	B	1	7.709	-	267.30	0.00	1	0.232	-	0	-	-	94.8668	EO	-
015257	1	B	17	1.404	0.053	53.65	2.05	6	2.256	0.068	11	2.214	0.192	93.9900	PL	0.131
015356	1	B	22	3.248	0.004	303.50	0.06	11	2.170	0.005	11	2.155	0.008	93.9820	PL	0.016
015869	1	B	11	2.265	0.015	278.44	0.33	5	1.890	0.028	6	1.862	0.020	93.9873	PL	0.092
015883	1	B	8	2.926	0.016	341.47	0.09	4	1.511	0.023	4	1.351	0.017	93.9847	PL	0.057
016080	1	B	11	12.852	0.004	311.37	0.01	7	1.729	0.006	4	1.504	0.004	92.8737	EO	0.044
017260	1	B	14	1.624	0.013	183.54	0.15	7	2.146	0.023	7	1.834	0.029	94.8614	EO	0.021

Table 3. continued.

Ident.	$N_{\rm obs}$	Cp	N	ρ_{V+I} ($''$)	σ_ρ ($''$)	θ_{V+I} ($^\circ$)	σ_θ ($^\circ$)	N_V	δm_V (mag)	$\sigma_{\delta m_V}$ (mag)	N_I	δm_I (mag)	$\sigma_{\delta m_I}$ (mag)	Date (year)	Obs.	$d_{\rm H}$ ($''$)
017288	1	B	8	1.368	0.025	292.07	0.75	5	2.562	0.038	3	2.505	0.046	94.8725	EO	0.195
017328	1	B	8	1.864	0.007	251.96	0.28	4	1.364	0.017	4	1.271	0.025	93.9901	PL	0.046
017397	1	B	25	6.253	0.002	179.36	0.01	2	2.516	0.009	23	2.227	0.002	92.8737	EO	0.007
017436	1	B	3	5.003	0.035	349.51	0.05	3	2.978	0.017	0	-	-	93.9873	PL	0.018
017464	1	B	10	4.975	0.004	16.97	0.04	10	3.092	0.002	0	-	-	93.9901	PL	0.027
018068	2	B	12	10.602	0.004	300.50	0.03	7	1.987	0.007	5	2.369	0.003	93.9820	PL	0.010
018429	2	B	11	1.833	0.002	35.07	0.12	3	0.062	0.003	8	-0.147	0.084	93.9793	PL	0.009
018452	1	B	2	4.190	0.001	139.51	0.06	0	-	-	2	0.622	0.001	94.8643	EO	0.010
018883	1	B	6	1.889	0.003	103.63	0.05	3	0.356	0.003	3	0.417	0.005	93.9901	PL	0.024
019684	2	B	7	1.652	0.003	50.76	0.22	2	0.081	0.013	5	0.133	0.008	93.9793	PL	0.047
019827	1	B	3	10.950	0.008	163.05	0.06	1	1.909	-	2	1.441	0.001	92.8710	EO	0.008
019892	1	B	15	3.318	0.002	8.49	0.03	10	1.784	0.003	5	1.314	0.004	94.8588	EO	0.022
019951	1	B	9	2.030	0.006	348.91	0.10	3	0.402	0.008	6	0.467	0.019	93.9794	PL	0.015
020020	2	B	30	4.099	0.005	2.88	0.03	17	1.701	0.014	13	1.579	0.048	93.9848	PL/EO	0.029
020374	1	B	15	2.485	0.032	143.35	0.19	8	3.052	0.042	7	3.156	0.086	93.9875	PL	0.205
020735	1	B	9	2.904	0.011	183.45	0.06	4	1.150	0.016	5	1.024	0.008	93.9875	PL	0.046
020766	1	B	17	1.358	0.025	133.37	1.20	7	2.477	0.046	10	2.735	0.097	93.9901	PL	0.150
020943	1	B	5	9.971	0.003	117.26	0.02	2	1.963	0.006	3	1.771	0.003	92.8711	EO	0.028
020956	1	B	9	5.915	0.002	320.33	0.01	9	1.891	0.002	0	-	-	92.8683	EO	0.026
021078	1	B	11	9.502	0.001	255.22	0.01	0	-	-	11	1.065	0.009	94.8698	EO	0.015
021213	1	B	7	3.155	0.007	222.04	0.05	4	1.753	0.006	3	1.613	0.016	93.9876	PL	0.050
021577	1	B	8	9.905	0.005	108.20	0.02	4	1.858	0.007	4	1.776	0.010	93.9874	PL	12.033
021849	1	B	27	3.661	0.005	229.40	0.06	17	2.482	0.005	10	2.279	0.003	93.9876	PL	0.027
022249	1	B	20	2.541	0.009	46.49	0.16	10	2.617	0.014	10	2.366	0.015	93.9902	PL	0.126
022359	1	B	15	4.813	0.010	259.77	0.05	0	-	-	15	2.310	0.012	94.8644	EO	0.029
022463	1	B	4	4.108	0.006	47.90	0.06	3	0.788	0.004	1	0.673	-	92.8738	EO	0.011
022874	1	B	5	6.132	0.003	138.46	0.02	2	0.267	0.000	3	0.230	0.003	92.8711	EO	0.008
023196	1	B	12	9.914	0.002	111.99	0.01	5	1.822	0.004	7	1.667	0.002	94.8726	EO	0.025
023480	1	B	7	3.290	0.016	262.22	0.08	2	1.505	0.037	5	1.455	0.005	92.8739	EO	0.027
023493	1	B	8	3.685	0.003	103.04	0.03	1	1.529	-	7	1.278	0.003	94.8590	EO	0.011
023567	1	B	1	5.550	-	80.16	0.00	1	0.697	-	0	-	-	92.8711	EO	0.011
023644	1	B	6	1.012	0.002	240.08	0.41	3	0.539	0.009	3	0.422	0.021	93.9903	PL	0.072
024039	1	B	31	5.381	0.007	211.53	0.03	15	4.674	0.013	16	3.470	0.004	92.8684	EO	-
024203	1	B	16	1.623	0.016	179.94	0.21	7	1.252	0.011	9	2.041	0.030	94.8616	EO	0.051
024366	1	B	15	7.757	0.002	108.06	0.01	11	1.712	0.003	4	1.711	0.001	92.8739	EO	0.020
024429	1	B	9	1.509	0.002	357.64	0.16	6	-0.026	0.005	3	0.065	0.032	93.9903	PL	0.014
024717	1	B	16	2.109	0.006	209.05	0.15	8	1.755	0.018	8	1.884	0.020	93.9821	PL	0.037
025231	1	B	15	1.009	0.015	343.92	1.14	7	1.504	0.060	8	1.168	0.091	93.9903	PL	0.102
025340	1	B	6	2.721	0.004	321.42	0.08	5	1.033	0.004	1	1.005	-	92.8712	EO	0.014
025482	1	B	7	1.353	0.007	163.96	0.42	4	0.516	0.014	3	0.298	0.028	93.9903	PL	0.032
026401	1	B	9	3.942	0.001	115.89	0.03	5	0.865	0.001	4	0.707	0.002	92.8739	EO	0.010
027174	1	B	11	2.005	0.005	301.07	0.14	5	1.649	0.020	6	1.498	0.018	93.9904	PL	0.043
027386	1	B	6	1.132	0.002	216.43	0.34	2	0.043	0.038	4	0.157	0.009	94.8727	EO	0.027
027424	1	B	5	3.829	0.002	152.56	0.04	1	0.137	-	4	0.098	0.003	92.8712	EO	0.014
027427	1	B	23	7.320	0.002	16.51	0.01	12	2.568	0.003	11	2.069	0.002	94.8616	EO	0.013
027524	1	B	8	2.689	0.004	194.77	0.05	4	0.383	0.004	4	0.403	0.005	93.9821	PL	0.008
027526	1	B	8	5.560	0.003	173.31	0.03	4	0.180	0.003	4	0.143	0.003	93.9822	PL	0.012
027827	1	B	8	1.091	0.006	279.45	0.99	4	1.219	0.034	4	1.038	0.013	93.9904	PL	0.021
027922	1	B	18	10.462	0.003	19.99	0.01	9	3.109	0.003	9	2.484	0.003	93.9849	PL	0.100
027962	1	B	26	4.349	0.001	287.74	0.02	13	2.246	0.002	13	1.847	0.002	94.8727	EO	0.011
028165	1	B	11	1.660	0.002	221.42	0.16	3	0.486	0.013	8	0.375	0.007	93.9904	PL	0.049
028275	1	B	6	3.574	0.001	67.85	0.03	3	0.118	0.001	3	0.099	0.001	93.9849	PL	0.015
028383	1	B	7	1.855	0.021	8.74	0.14	3	0.931	0.021	4	0.773	0.062	93.9822	PL	0.051
028730	1	B	9	5.341	0.002	171.73	0.02	4	2.099	0.007	5	1.620	0.005	92.8712	EO	0.008
028819	1	B	10	1.312	0.012	63.19	0.85	5	1.632	0.041	5	1.525	0.045	93.9822	PL	0.053
028852	1	B	9	6.240	0.004	3.12	0.02	6	0.207	0.001	3	0.197	0.002	93.9877	PL	0.019
029383	1	B	3	7.338	0.001	306.70	0.01	0	-	-	3	0.428	0.003	94.8645	EO	-

Table 3. continued.

Ident.	$N_{\rm obs}$	Cp	N	ρ_{V+I} ($''$)	σ_ρ ($''$)	θ_{V+I} ($^\circ$)	σ_θ ($^\circ$)	N_V	δm_V (mag)	$\sigma_{\delta m_V}$ (mag)	N_I	δm_I (mag)	$\sigma_{\delta m_I}$ (mag)	Date (year)	Obs.	$d_{\rm H}$ ($''$)
029622	1	B	3	4.624	0.006	52.75	0.02	2	1.132	0.004	1	1.154	-	92.8685	EO	0.018
029811	1	B	9	1.812	0.008	284.55	0.39	5	1.321	0.029	4	1.362	0.027	93.9849	PL	0.043
030456	1	B	13	1.557	0.009	308.18	0.47	7	1.733	0.017	6	1.711	0.035	93.9905	PL	0.032
030593	1	B	11	8.527	0.006	227.53	0.02	6	1.765	0.002	5	1.638	0.006	93.9878	PL	0.032
030840	1	B	7	1.149	0.022	41.55	1.24	7	1.415	0.104	0	-	-	93.9905	PL	0.056
030925	1	B	12	2.787	0.007	119.81	0.08	6	1.561	0.011	6	1.571	0.012	93.9849	PL	0.033
031005	1	B	5	4.488	0.033	139.49	0.05	5	1.795	0.012	0	-	-	92.8659	EO	0.109
031042	1	B	22	11.630	0.004	33.42	0.01	11	1.401	0.002	11	1.183	0.004	92.8713	EO	0.030
031126	1	B	27	3.750	0.003	219.47	0.03	9	1.908	0.003	18	1.533	0.004	93.9796	PL	0.053
031506	1	B	11	9.637	0.002	206.39	0.01	5	2.406	0.002	6	2.335	0.002	94.8728	EO	0.073
031539	1	B	33	2.807	0.008	33.97	0.02	16	2.608	0.002	17	2.773	0.005	93.9823	PL	-
031634	1	B	11	2.227	0.015	203.17	0.22	6	2.787	0.027	5	2.181	0.006	93.9796	PL	0.103
031634	1	C	18	30.190	0.008	89.99	0.02	9	3.131	0.014	9	3.665	0.033	93.9796	PL	-
031833	1	B	11	5.053	0.002	24.29	0.01	11	1.441	0.002	0	-	-	92.8741	EO	0.027
032069	1	B	14	3.707	0.024	167.72	0.07	9	2.090	0.021	5	2.040	0.008	93.9850	PL	0.011
032111	1	B	20	2.532	0.026	191.79	0.26	10	3.035	0.059	10	2.512	0.041	93.9878	PL	0.138
032144a	2	B	30	18.130	0.004	144.46	0.03	13	2.079	0.024	17	1.870	0.046	93.9848	PL/EO	-
033177	1	B	20	3.159	0.001	275.17	0.01	10	0.557	0.002	10	0.577	0.002	92.8686	EO	0.005
033487	1	B	7	1.048	0.003	149.04	0.36	4	0.276	0.019	3	0.306	0.017	93.9905	PL	0.031
033499	1	B	4	1.656	0.061	68.00	2.73	4	2.915	0.017	0	-	-	93.9824	PL	1.795
033770	1	B	29	3.745	0.003	139.29	0.05	14	2.572	0.007	15	2.290	0.006	93.9878	PL	0.020
033900	1	B	8	5.120	0.003	109.95	0.06	4	0.357	0.004	4	0.343	0.019	93.9824	PL	0.012
033969	1	B	28	2.470	0.009	337.47	0.06	14	2.447	0.016	14	2.232	0.007	93.9906	PL	0.039
034000	1	B	4	1.444	0.007	84.43	0.31	4	0.954	0.034	0	-	-	93.9906	PL	0.032
034386	1	B	22	2.246	0.021	23.50	0.26	11	2.594	0.017	11	2.274	0.024	93.9851	PL	0.165
034586	1	B	7	1.692	0.008	218.98	0.17	3	0.827	0.018	4	0.776	0.018	93.9906	PL	0.032
034817	1	B	22	2.480	0.012	69.40	0.27	11	2.060	0.024	11	1.949	0.026	93.9851	PL	0.145
034898	1	B	14	6.636	0.003	97.06	0.02	7	2.242	0.002	7	2.068	0.003	93.9879	PL	0.011
034919	1	B	14	3.255	0.058	198.71	0.28	13	3.824	0.087	1	3.470	-	93.9852	PL	0.292
034933	1	B	6	3.645	0.002	40.79	0.03	6	1.337	0.001	0	-	-	94.8701	EO	0.009
035207	1	B	9	7.960	0.003	270.37	0.02	5	1.791	0.003	4	1.509	0.007	92.8714	EO	0.023
035391	1	B	5	3.023	0.005	77.35	0.05	4	0.234	0.003	1	0.243	-	93.9852	PL	0.008
035439	1	B	22	3.517	0.013	353.41	0.07	11	2.733	0.012	11	2.567	0.023	93.9852	PL	0.059
035539	1	B	4	1.979	0.006	116.14	0.60	1	0.778	-	3	0.793	0.006	93.9879	PL	0.046
035924	1	B	8	1.875	0.006	68.16	0.23	4	0.017	0.004	4	0.011	0.006	93.9825	PL	0.044
035960	1	B	4	6.879	0.002	322.26	0.01	2	0.068	0.001	2	0.119	0.004	94.8701	EO	0.007
036013	1	B	22	1.623	0.010	37.36	0.19	11	1.675	0.013	11	1.527	0.027	93.9907	PL	0.076
036108	1	B	8	1.249	0.011	72.33	1.11	4	1.086	0.052	4	0.797	0.032	93.9825	PL	0.045
036442	1	B	9	1.334	0.020	296.48	1.19	5	2.221	0.046	4	2.640	0.162	93.9880	PL	0.179
038137	1	B	8	2.166	0.007	85.60	0.33	4	1.129	0.008	4	1.088	0.014	93.9825	PL	0.040
039290	1	B	8	6.038	0.004	297.01	0.04	4	1.107	0.002	4	1.070	0.020	93.9825	PL	0.016
039498	1	B	14	1.311	0.009	264.55	0.91	7	1.361	0.035	7	1.304	0.076	93.9825	PL	0.031
042581a	1	B	3	29.495	0.013	303.16	0.02	3	2.172	0.016	0	-	-	93.9797	PL	-
043422	1	B	9	2.034	0.004	143.52	0.06	3	0.284	0.003	6	0.207	0.010	93.9799	PL	-
043539	1	B	5	2.856	0.014	324.22	0.09	5	1.750	0.019	1	1.61:	-	93.9881	PL	0.024
043708	1	B	3	1.715	0.024	108.36	7.30	2	3.892	0.084	3	3.409	0.028	93.9799	PL	-
043920	1	B	6	3.865	0.005	182.33	0.02	3	0.125	0.001	3	0.125	0.007	93.9881	PL	0.046
044429	1	B	7	6.122	0.007	321.63	0.02	3	3.014	0.003	4	2.834	0.004	93.9909	PL	0.043
044776	1	B	27	3.574	0.003	122.81	0.06	14	2.820	0.004	13	2.549	0.004	93.9854	PL	0.019
045582	1	B	6	4.431	0.005	341.42	0.02	3	0.435	0.001	3	0.410	0.001	93.9909	PL	0.011
055736	1	B	10	3.640	0.002	40.85	0.03	5	1.339	0.004	5	1.275	0.002	94.8701	EO	-
077311	1	B	21	10.551	0.002	179.69	0.01	11	3.014	0.003	10	2.590	0.002	92.6268	PL	0.054
078163	1	B	5	5.927	0.005	39.32	0.03	2	1.243	0.005	3	1.076	0.005	92.6268	PL	0.021
079329	1	B	11	14.670	0.004	6.13	0.01	3	1.010	0.003	8	0.131	0.002	94.6337	PL	0.076
079902	1	B	16	3.757	0.006	344.12	0.04	0	-	-	16	2.985	0.004	92.6270	PL	-
079960	1	B	6	3.794	0.005	347.11	0.03	3	0.976	0.001	3	0.720	0.006	92.6268	PL	0.014
080540	1	B	6	4.304	0.002	269.94	0.02	3	0.231	0.001	3	0.255	0.005	92.6269	PL	0.005

Table 3. continued.

Ident.	$N_{\rm obs}$	Cp	N	ρ_{V+I} ($''$)	σ_ρ ($''$)	θ_{V+I} ($^\circ$)	σ_θ ($^\circ$)	N_V	δm_V (mag)	$\sigma_{\delta m_V}$ (mag)	N_I	δm_I (mag)	$\sigma_{\delta m_I}$ (mag)	Date (year)	Obs.	$d_{\rm H}$ ($''$)
081227	1	B	13	4.517	0.005	65.11	0.03	5	0.951	0.002	8	-0.622	0.001	94.6311	PL	0.008
083530	1	B	33	5.534	0.002	257.78	0.02	16	2.549	0.003	17	2.443	0.002	92.6242	PL	-
085306	1	B	11	4.225	0.021	111.13	0.16	5	2.215	0.003	6	2.759	0.029	92.6214	PL	0.077
085685	2	B	17	4.810	0.001	339.60	0.02	12	1.135	0.025	5	1.122	0.001	92.6215	PL	0.016
086632	2	B	13	4.619	0.002	124.45	0.02	5	0.231	0.001	8	0.201	0.001	92.6296	PL	0.007
087176	1	B	29	3.728	0.002	218.44	0.02	14	2.234	0.002	15	1.806	0.001	92.6271	PL	0.047
087535	1	B	6	3.621	0.001	230.65	0.01	3	0.969	0.001	3	0.875	0.001	92.6296	PL	0.006
087718	1	B	26	7.649	0.003	67.51	0.03	13	2.638	0.003	13	3.050	0.002	92.6271	PL	0.046
087914	1	B	5	2.897	0.003	34.23	0.06	3	0.576	0.004	2	0.343	0.008	92.6296	PL	0.045
088203	1	B	12	3.782	0.006	233.03	0.04	6	2.175	0.002	6	2.573	0.016	92.6297	PL	0.010
088603	2	B	12	5.194	0.002	283.97	0.06	6	2.607	0.004	6	2.062	0.003	94.6312	PL	0.023
090189	2	B	11	3.313	0.004	180.06	0.01	3	0.152	0.002	8	0.047	0.001	92.6297	PL	0.030
090574	1	B	7	2.607	0.002	105.15	0.04	3	0.091	0.005	4	0.086	0.003	92.6272	PL	0.016
090787	1	B	8	7.467	0.002	76.28	0.01	3	0.334	0.001	5	0.267	0.003	92.6298	PL	0.027
091380	2	B	29	4.405	0.001	177.77	0.01	19	2.186	0.005	10	2.153	0.001	94.6394	PL	0.014
091754	2	B	9	2.211	0.003	208.86	0.11	6	1.204	0.013	3	1.057	0.003	92.6298	PL	0.012
092415	1	B	25	15.821	0.003	221.33	0.00	12	3.756	0.002	13	3.571	0.002	92.6243	PL	-
092560	1	B	28	13.026	0.003	36.79	0.01	14	2.437	0.001	14	2.397	0.002	92.6215	PL	0.036
093069	1	B	6	3.050	0.002	337.75	0.02	3	0.509	0.005	3	0.341	0.003	92.6298	PL	0.048
093521	1	B	8	5.721	0.004	76.95	0.01	4	1.237	0.002	4	0.822	0.002	92.6216	PL	0.016
093970	1	B	6	2.748	0.002	25.14	0.02	3	0.136	0.002	3	0.128	0.001	92.6300	PL	0.016
094307	1	B	25	13.954	0.001	151.86	0.01	11	3.194	0.002	14	2.669	0.001	92.6217	PL	0.109
095097	1	B	4	10.743	0.004	230.58	0.01	2	1.344	0.000	2	1.158	0.000	92.6244	PL	0.047
095493	1	B	6	4.059	0.002	14.92	0.02	3	0.026	0.002	3	0.017	0.001	92.6299	PL	-
096667	1	B	8	9.984	0.006	235.72	0.02	4	0.062	0.003	4	0.042	0.003	92.6189	PL	0.055
096915	1	B	6	6.577	0.005	31.82	0.02	3	0.880	0.001	3	0.509	0.001	92.6244	PL	0.045
097301	1	B	16	3.322	0.005	132.21	0.05	11	2.800	0.008	5	2.381	0.004	92.6190	PL	0.034
097570	1	B	14	6.736	0.003	270.56	0.02	7	2.388	0.003	7	2.059	0.002	92.6244	PL	-
097593a	1	B	7	13.939	0.008	318.56	0.07	4	4.554	0.027	3	4.755	0.002	92.6217	PL	-
100182	1	B	27	4.972	0.001	278.42	0.01	13	2.203	0.002	14	1.673	0.002	92.6272	PL	0.014
100449	1	B	12	15.936	0.003	346.69	0.00	6	2.277	0.003	6	2.203	0.003	94.6396	PL	0.697
101317	1	B	5	3.473	0.002	89.58	0.03	2	0.055	0.003	3	0.038	0.001	92.6300	PL	0.013
101653	1	B	21	12.512	0.002	259.13	0.01	4	3.603	0.003	17	3.686	0.002	92.6218	PL	-
102467	1	B	6	11.868	0.003	287.59	0.01	3	2.858	0.003	3	2.832	0.006	92.6301	PL	0.141
102532/1a	1	B	7	9.349	0.009	266.60	0.05	3	0.937	0.002	4	1.333	0.006	92.6191	PL	-
103438	1	B	6	4.490	0.002	259.98	0.04	3	0.461	0.002	3	0.220	0.029	92.6301	PL	0.034
103475	1	B	5	5.890	0.001	308.39	0.01	2	0.331	0.001	3	0.583	0.001	92.6245	PL	0.007
104370	1	B	6	2.450	0.004	182.31	0.04	3	0.369	0.006	3	0.302	0.010	92.6301	PL	0.012
104582	1	B	6	5.231	0.002	239.08	0.01	3	1.466	0.001	3	1.412	0.003	92.6245	PL	0.021
105692	1	B	32	3.517	0.002	352.74	0.01	16	1.851	0.002	16	1.782	0.002	92.6274	PL	0.024
105842	1	B	26	4.700	0.002	131.14	0.02	13	2.814	0.004	13	2.290	0.003	92.6274	PL	0.041
106411	1	B	8	5.943	0.002	62.47	0.01	4	0.815	0.002	4	0.640	0.001	92.6246	PL	0.019
106602	1	B	13	9.308	0.003	2.35	0.01	6	1.143	0.002	7	0.743	0.002	92.6246	PL	0.057
107206	1	B	7	5.589	0.001	97.63	0.01	4	0.389	0.004	3	0.346	0.002	92.6302	PL	0.016
107658	1	B	11	5.393	0.001	97.03	0.01	5	1.433	0.002	6	1.026	0.002	92.6246	PL	0.016
108801	1	B	16	10.448	0.007	202.11	0.02	8	1.739	0.004	8	1.554	0.003	92.6274	PL	0.032
109156	1	B	4	7.804	0.001	294.62	0.03	0	-	-	4	3.604	0.003	92.6248	PL	-
109183	1	B	7	3.604	0.004	136.43	0.05	4	1.203	0.001	3	1.004	0.003	92.6275	PL	0.006
109840	1	B	12	2.307	0.006	177.69	0.12	6	1.948	0.023	6	1.589	0.009	92.6275	PL	0.022
110654	1	B	8	12.627	0.006	244.39	0.01	4	1.523	0.002	4	1.303	0.003	92.8679	EO	0.044
111231	1	B	5	6.463	0.007	356.49	0.02	4	1.720	0.003	1	1.473	-	92.8732	EO	0.029
111687	1	B	20	11.015	0.001	354.74	0.01	10	2.648	0.001	10	2.692	0.002	92.6303	PL	0.053
112220	1	B	6	10.764	0.004	248.68	0.01	3	1.107	0.002	3	1.072	0.003	92.6219	PL	0.038
112815	1	B	11	3.029	0.001	58.94	0.01	5	0.088	0.001	6	0.079	0.001	94.6344	PL	0.001
112865	1	B	6	7.608	0.002	170.89	0.01	3	0.579	0.003	3	0.520	0.001	92.6219	PL	0.028
113386	1	B	18	9.107	0.001	343.28	0.01	9	1.604	0.001	9	1.555	0.001	94.8719	EO	0.018
113537	1	B	12	8.790	0.002	279.93	0.01	6	1.258	0.002	6	1.159	0.003	92.6248	PL	0.015

Table 3. continued.

Ident.	$N_{\rm obs}$	Cp	N	ρ_{V+I} ($''$)	σ_ρ ($''$)	θ_{V+I} ($^\circ$)	σ_θ ($^\circ$)	N_V	δm_V (mag)	$\sigma_{\delta m_V}$ (mag)	N_I	δm_I (mag)	$\sigma_{\delta m_I}$ (mag)	Date (year)	Obs.	$d_{\rm H}$ ($''$)
113984	1	B	6	7.628	0.001	50.87	0.01	3	0.126	0.002	3	0.192	0.001	92.6220	PL	0.025
114167	1	B	8	8.794	0.001	254.62	0.01	3	0.797	0.001	5	0.745	0.001	92.6194	PL	0.047
114378a	1	B	3	31.362	0.019	270.08	0.03	3	3.592	0.007	0	-	-	92.6248	PL	-
114857	1	B	22	3.664	0.010	281.78	0.07	13	2.773	0.008	9	2.980	0.019	92.6303	PL	0.044
115290	1	B	4	3.406	0.004	225.15	0.02	4	0.857	0.002	0	-	-	92.8732	EO	0.012
115863	1	B	12	2.881	0.003	42.02	0.06	6	1.728	0.006	6	1.641	0.007	92.6303	PL	0.051
116068	1	B	11	10.178	0.001	297.05	0.00	5	1.586	0.001	6	1.508	0.002	92.6248	PL	0.045
116329	1	B	10	5.881	0.001	71.57	0.02	5	1.576	0.002	5	1.350	0.001	94.8747	EO	0.010
116662	1	B	20	3.063	0.001	201.52	0.02	15	1.383	0.001	5	1.235	0.002	94.6344	PL	0.023
116737	1	B	8	3.885	0.002	276.45	0.01	4	0.767	0.003	4	0.673	0.001	92.6195	PL	0.020
116748	1	B	8	5.306	0.005	347.81	0.02	4	1.173	0.002	4	0.878	0.003	92.6304	PL	0.022
116785	1	B	7	7.453	0.002	143.96	0.02	4	0.746	0.002	3	0.669	0.002	92.6220	PL	0.038
117063	1	B	9	3.095	0.003	3.67	0.06	5	0.230	0.005	4	0.210	0.011	94.8748	EO	0.021
117081	1	B	9	6.377	0.002	341.20	0.01	5	0.092	0.003	4	0.074	0.002	94.8637	EO	-
117269	1	B	10	2.352	0.002	162.79	0.01	4	0.039	0.076	6	0.064	0.003	92.8733	EO	0.017
117316	1	B	11	7.114	0.001	358.02	0.01	0	-	-	11	2.954	0.002	92.6250	PL	-
117545	1	B	13	11.522	0.002	56.08	0.01	7	1.980	0.002	6	1.828	0.001	92.6221	PL	0.075
117598	1	B	28	2.944	0.004	14.75	0.03	14	2.473	0.006	14	2.277	0.005	92.8733	EO	0.037
117676	1	B	24	5.212	0.005	69.16	0.02	12	3.027	0.010	12	3.289	0.054	94.8749	EO	0.052
ADS 6223	1	C	15	7.660	0.008	300.82	0.03	6	1.306	0.003	9	1.118	0.022	93.9798	PL	-
–1504995a	1	B	3	8.818	0.006	188.45	0.02	3	0.031	0.001	0	-	-	92.6243	PL	-
+0701054a	1	B	4	18.642	0.004	72.98	0.02	0	-	-	4	0.131	0.025	94.8646	EO	-
+1303203a	1	B	37	12.762	0.003	333.82	0.01	20	0.484	0.006	17	0.414	0.005	92.6185	PL	-
NGC 1647Ia	1	B	6	50.951	0.012	33.42	0.02	3	1.427	0.008	3	1.153	0.006	93.9794	PL	-
NGC 1647Ia	1	C	6	37.234	0.011	333.51	0.02	3	1.464	0.006	3	1.430	0.009	93.9794	PL	-
SAO 244567	1	B	15	35.624	0.005	75.26	0.01	6	1.073	0.008	9	3.687	0.008	92.6296	PL	-
SAO 244567	1	C	15	17.719	0.008	202.60	0.02	6	4.903	0.001	9	5.952	0.008	92.6296	PL	-

For NGC 1647I, B read: Cl* NGC 1647 H 46 wrt. Cl* NGC 1647 H 45.
For NGC 1647I, C read: Cl* NGC 1647 H 43 wrt. Cl* NGC 1647 H 45.

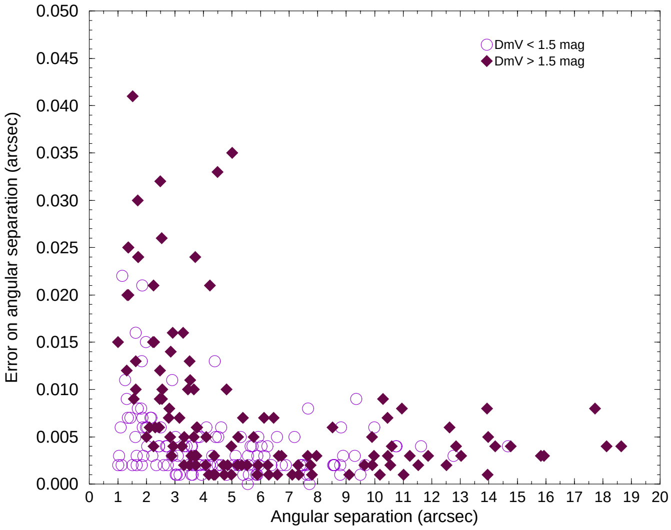

Fig. 1. Internal errors on separation vs. angular separation for two classes of Δm.

position angle will refer to their mean taken in both filters V and i. N_V and N_I are the number of frames taken in V and i respectively. Mean values are listed in case of repeated observations of the same double star on a different night. In addition, an observation of ADS 6223 and SAO 244567, which appeared as a "wide" triple system, had been requested. Such data are listed at the end of each table. Negative detections (no components found) are not listed: this concerns HIP 1876 (on 16/08/92 and 18/08/94), HIP 21765 (on 23/12/93) and HIP 31711 (on 25/12/93).

The last column gives the difference between the CCD and the Hipparcos relative position in arcsec. This "distance" or difference between the two measurements in position of the secondary with respect to the primary component, $d_{\rm H}$, may be computed as

$$d_{\rm H} = \sqrt{\rho_{\rm ccd}^2 + \rho_{\rm H}^2 - 2\rho_{\rm ccd}\rho_{\rm H}\cos(\theta_{\rm ccd} - \theta_{\rm H})}. \qquad (1)$$

In one case a different component than the one measured by Hipparcos was evidently observed (HIP 21577). The agreement is generally excellent as shown in a previous analysis based on a set of some 400 observed visual double stars (Oblak et al. 1997). In total, some 50 campaigns were performed in various observatories. This paper is the second one of the series grouping the data of five missions alltogether. It seems therefore preferable to us to

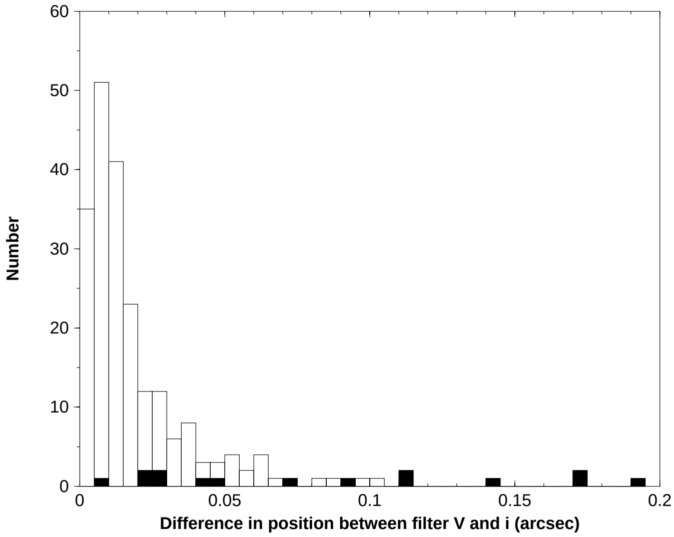

Fig. 2. Distribution of differences in relative position, d, between filters V and i for the 225 systems discussed in the text. Black fields represent the 15 systems with $\rho < 3''$ and $\Delta i > 2$ mag.

postpone the comparison between the CCD and the Hipparcos relative positions until after all the network results are available. Nonetheless, we hereby list d_{H} to illustrate the overall quality of our data.

5. Presentation of standard photometry data

Not all our nights were of photometric quality. The results presented in Table 4 only concern those observations that were acquired in "reasonable" or good photometric conditions. This comprises standard V magnitudes and $(V-I)$ colour indices for the components of 203 Hipparcos double stars, one apparently double (the triple system ADS 6223) and 9 astrometric standard stars. Also presented are the magnitude differences, ΔV and $\Delta(V-I)$, between the components A and B of each system in the Cousins *standard* system. The first columns list the identifier (same as before), the Julian date, and the previously cited data along with standard deviations on all parameters. In the case that only one colour was obtained, one must note that the listed component magnitudes and differences, ΔV or Δi, are less accurate: in that case a default value of 0.7 for $(V-I)_{\mathrm{A}}$ and $(V-I)_{\mathrm{B}}$ was adopted in the reduction (as done in the standard Hipparcos double star processing). Such data are e.g. presented separately in Table 5 (filter I only). These results will be discussed and illustrated in Sect. 6.4.

6. Discussion of the errors

6.1. Internal errors on the astrometry

Because each frame was repeated at least three times, we provide statistics on the internal consistency of the data (in the form of standard deviations). A first example is shown in Fig. 1 where the internal errors on angular separation have been plotted as a function of angular separation for two different ranges of ΔV. There is a very clear dependence on both angular separation and difference of magnitude in the sense that the mean error is larger for decreasing separation and increasing differential magnitude while it increases slightly again at the largest separations. The mean error for all 253 data is $0.0073''$ with a standard deviation of $0.0122''$ This is somewhat higher than expected (Lampens et al. 1997): the reason is the significant amount of systems with small separation and large magnitude difference. After having selected 217 data with angular separation $\geq 3''$ or $\Delta V \leq 1.5$ mag, the mean error becomes $0.0057''$ with a standard deviation of $0.0113''$. Similarly the mean error in position angle decreases from 0.167° to 0.076° while the standard deviation decreases from 0.561° to 0.167°. Internal errors are much larger in the case of systems with angular separation $<3''$ and $\Delta V > 1.5$ mag: the mean error in separation for the 36 remaining systems is $0.0171''$ and the mean error in position angle is then 0.719°. We may safely state that mean astrometric errors vary from *pixel width* ×0.01 in the best cases to *pixel width* ×0.05 in the worst ones.

Internal errors on the astrometry may also be discussed from a consistency check between the observation sequences made in several filters. We verified the assumption that relative positions are independent from the filter choice by computing the "distance" d, i.e. the difference in relative positions for the filters V and i, as

$$d = \sqrt{\rho_V^2 + \rho_i^2 - 2\rho_V\rho_i\cos(\theta_V - \theta_i)}. \qquad (2)$$

Figure 2 shows the distribution of these values d where 225 data are represented with a mean difference of $0.022''$ and a standard deviation of $0.029''$. After elimination of 15 systems with a separation smaller than $3''$ and a differential i (and V in most cases) magnitude larger than 2 mag, the mean value decreases to $0.018''$ with a standard deviation of $0.018''$. This is larger than the mean internal error but probably reflects the true error of our measurements. This peak value is also larger by about $0.007''$ than the one determined in Paper II, again principally due to the significant number of double stars of separation smaller than $2''$ in our sample (we count 39 such systems, 15 of which have $\Delta V > 1.5$ mag, compared to 4 in Paper II). The largest inconsistencies are found for the more difficult configurations of smaller separation and larger magnitude difference: this is reflected by a mean difference of $0.084''$ and a standard deviation of $0.061''$ for the 15 previously mentioned data points. We also verified whether any systematics occurs between angular separations measured in both filters. A simple statistical test shows that the distribution for 207 data points is different from a normal distribution with zero mean at the 0.05 significance level ($\overline{(\rho_V - \rho_i)}$ of $-0.0025''$; σ of $0.018''$), in the sense that separations appear generally somewhat larger in the filter i: this effect is best seen for separations larger than

Table 4. CCD VI photometry for 203 Hipparcos and 9 astrometric standard double stars.

Identifier	Jul. Dat. 2440000+	n_V	$V_{\rm A}$ (mag)	$\sigma_{V_{\rm A}}$ (mag)	$V_{\rm B}$ (mag)	$\sigma_{V_{\rm B}}$ (mag)	n_I	$(V-I)_{\rm A}$ (mag)	$\sigma_{(V-I)_{\rm A}}$ (mag)	$(V-I)_{\rm B}$ (mag)	$\sigma_{(V-I)_{\rm B}}$ (mag)	ΔV (mag)	$\Delta\,(V-I)$ (mag)
000045	8852.8460	7	9.755	.020	11.791	.022	7	.78	.03	1.32	.03	2.036	.55
000169	8851.8217	3	9.523	.020	10.885	.020	3	1.62	.03	1.96	.03	1.362	.34
000924	8849.8117	6	9.349	.060	11.150	.060	0	-	-	-	-	1.801	-
000924	8850.8464	6	9.155	.020	11.063	.020	7	.79	.03	1.29	.03	1.907	.50
001186	8852.8973	3	10.190	.021	11.351	.025	1	.68	.03	.75	.03	1.162	.07
002438	8852.9290	5	10.247	.020	13.225	.020	14	.56	.03	1.13	.03	2.978	.57
002438	9668.5774	2	10.244	.025	13.188	.025	0	-	-	-	-	2.944	-
002449	9668.5911	2	10.362	.051	10.839	.051	2	.72	.05	.63	.05	.477	−.09
002663	9670.5833	10	6.655	.025	8.590	.025	10	.65	.04	.92	.04	1.935	.27
003200	8851.8605	4	10.076	.020	11.357	.020	4	.63	.03	.73	.03	1.280	.10
003205	8851.8674	3	10.011	.020	10.223	.020	1	.52	.03	.46	.03	.212	−.06
003397	8848.8919	11	6.970	.030	10.573	.031	12	.51	.04	.18	.05	3.603	−.34
003827	8850.8527	2	9.640	.020	10.052	.020	3	.65	.03	.68	.03	.412	.03
004404	8850.8689	13	9.057	.020	12.388	.022	14	.59	.03	1.12	.03	3.332	.53
004764	9346.4528	6	9.698	.044	11.043	.134	3	.82	.06	1.04	.18	1.344	.23
005413	9346.4701	13	9.401	.020	11.657	.020	13	.22	.03	.97	.03	2.256	.75
005992	9670.6241	6	6.461	.025	8.314	.026	7	.02	.04	.46	.04	1.853	.44
006132	8851.8921	11	10.316	.020	12.270	.020	12	.69	.03	.89	.03	1.954	.20
006707	8941.6132	11	8.380	.019	9.762	.019	9	.44	.02	.56	.02	1.382	.12
007290	8851.9007	7	9.918	.020	12.998	.025	4	1.12	.03	2.52	.03	3.081	1.40
008054	8939.6481	7	9.902	.036	11.363	.036	4	.71	.04	.87	.04	1.461	.15
008236	8850.8941	4	9.952	.020	12.743	.020	4	.63	.03	1.00	.03	2.792	.37
008957	9347.4322	3	7.157	.017	7.249	.017	3	.35	.02	.40	.02	.093	.05
008965	9347.4362	3	8.825	.025	10.693	.100	3	.05	.04	.59	.17	1.868	.54
009258	9670.6556	6	7.194	.025	7.628	.026	2	.47	.04	.64	.04	.434	.17
009344	8850.9127	3	9.779	.020	9.987	.020	3	.53	.03	.55	.03	.208	.02
009651	8850.9180	3	9.960	.020	10.181	.020	3	.66	.03	.73	.03	.221	.07
010579	9668.6298	5	9.432	.020	9.905	.020	4	.64	.03	.73	.03	.473	.09
010683	8939.6568	4	8.130	.020	8.943	.020	3	.57	.03	.61	.03	.813	.04
010722	9347.4501	7	8.395	.025	10.518	.129	6	1.02	.03	.32	.17	2.123	−.70
010983	9669.6681	14	7.503	.026	10.669	.043	18	1.01	.04	.55	.06	3.166	−.45
011219	9668.7130	10	8.864	.020	10.129	.020	0	-	-	-	-	1.265	-
011257	9668.6486	4	9.124	.020	9.357	.020	5	.57	.03	.58	.03	.233	.02
011945	9348.4323	3	7.877	.017	7.980	.017	3	1.07	.02	1.05	.02	.103	−.02
012105	9668.7052	6	7.055	.021	8.922	.021	4	.95	.03	.24	.03	1.867	−.72
012708	9347.4560	3	6.998	.020	7.270	.021	5	−.09	.03	−.04	.03	.272	.04
012752	8939.7298	4	9.781	.024	10.891	.031	8	.75	.03	.80	.04	1.110	.05
013199	9348.4429	6	9.470	.017	9.831	.017	3	.52	.02	.47	.02	.361	−.05
013243	9345.4744	5	9.653	.021	9.773	.021	6	.78	.03	.84	.03	.120	.06
013815	9347.4836	13	8.250	.019	10.645	.073	14	−.03	.03	−.01	.09	2.395	.03
013866	9668.6967	6	10.013	.020	11.689	.020	4	.52	.03	.72	.03	1.676	.20
014584	9346.4783	12	9.553	.020	10.659	.020	2	.92	.03	.90	.03	1.106	−.02
015257	9349.4358	11	8.433	.018	10.689	.048	12	1.03	.03	1.09	.17	2.256	.06
015356	9346.5003	11	9.029	.020	11.205	.021	11	.40	.03	.54	.03	2.176	.14
015869	9348.4497	15	7.070	.017	8.963	.022	15	.18	.02	.23	.03	1.893	.05
015883	9347.4997	5	7.308	.018	8.848	.024	5	.25	.02	.62	.03	1.540	.36
016080	8941.7033	7	8.091	.019	9.853	.019	5	.53	.03	.79	.03	1.762	.26
017260	9347.5039	6	7.925	.026	8.871	.047	5	.30	.04	.69	.07	.946	.39
017288	9670.7485	5	7.815	.025	10.377	.030	0	-	-	-	-	2.562	-
017328	9349.4562	4	6.662	.017	8.042	.021	4	−.03	.02	.18	.03	1.381	.21

Table 4. continued.

Identifier	Jul. Dat. 2440000+	n_V	V_A (mag)	σ_{V_A} (mag)	V_B (mag)	σ_{V_B} (mag)	n_I	$(V-I)_\mathrm{A}$ (mag)	$\sigma_{(V-I)_\mathrm{A}}$ (mag)	$(V-I)_\mathrm{B}$ (mag)	$\sigma_{(V-I)_\mathrm{B}}$ (mag)	ΔV (mag)	$\Delta\,(V-I)$ (mag)
017397	8941.7226	13	9.532	.021	12.091	.021	23	.24	.03	.57	.03	2.559	.33
017436	9348.4574	11	6.549	.017	9.527	.019	0	-	-	-	-	2.978	-
017464	9349.4610	10	6.373	.017	9.465	.017	0	-	-	-	-	3.092	-
018068	9346.5063	7	8.000	.020	9.987	.021	0	-	-	-	-	1.987	-
018429	9345.5112	3	10.431	.021	10.495	.021	3	1.04	.03	1.07	.03	.063	.03
018883	9349.4728	3	8.321	.017	8.666	.017	3	.56	.02	.42	.02	.345	−.14
019684	9345.5212	3	8.194	.021	8.275	.021	0	-	-	-	-	.081	-
019892	9668.7629	10	7.387	.020	9.181	.020	5	−.01	.03	.52	.03	1.795	.52
019951	9345.5550	3	9.616	.020	10.014	.020	6	.77	.03	.66	.03	.397	−.12
020020	9347.5166	8	5.987	.018	7.685	.019	7	−.26	.02	−.12	.03	1.698	.15
020020	9669.7071	10	6.085	.029	7.808	.029	6	−.13	.04	.07	.04	1.723	.20
020374	9348.5275	8	7.657	.017	10.698	.043	9	1.09	.02	.89	.09	3.042	−.20
020735	9348.5139	4	7.053	.018	8.216	.021	7	−.02	.02	.23	.03	1.163	.24
020766	9349.4779	10	7.844	.017	10.322	.039	11	1.04	.03	.66	.10	2.478	−.37
020943	8940.7505	11	10.255	.050	12.218	.051	0	-	-	-	-	1.963	-
020956	8939.7424	10	10.363	.022	12.254	.023	0	-	-	-	-	1.891	-
021213	9348.5338	4	7.848	.017	9.615	.018	5	.18	.02	.45	.03	1.767	.27
021577	9348.4838	4	7.181	.017	9.047	.018	7	.33	.02	.49	.03	1.866	.16
021849	9348.5500	11	7.474	.017	9.976	.018	11	.22	.02	.61	.02	2.502	.39
022249	9349.4970	10	7.328	.017	9.990	.021	10	.53	.02	1.10	.03	2.662	.57
022463	8941.7542	3	8.958	.015	9.763	.016	2	.51	.02	.64	.02	.805	.13
022874	8940.7584	3	10.039	.053	10.312	.053	3	.53	.07	.57	.07	.273	.04
023196	9670.7778	5	7.194	.027	9.026	.027	7	.43	.04	.60	.04	1.832	.17
023480	8941.7664	5	8.008	.018	9.457	.040	5	.26	.02	.26	.04	1.449	−.01
023493	9668.8104	1	7.094	.020	8.629	.020	7	−.11	.03	.17	.03	1.535	.28
023644	9349.5198	3	8.912	.017	9.472	.018	3	.70	.03	.96	.03	.560	.27
024039	8939.7794	18	9.525	.021	14.402	.031	17	.78	.03	2.20	.04	4.877	1.42
024203	9669.7795	7	6.245	.029	7.446	.029	9	1.00	.04	.11	.04	1.201	−.89
024366	8941.7834	11	9.369	.015	11.081	.016	7	.73	.02	.73	.02	1.712	.00
024429	9349.5306	6	10.112	.018	10.070	.018	3	.60	.03	.39	.03	−.042	−.21
024717	9346.5535	8	9.171	.020	10.916	.025	8	.94	.03	.71	.04	1.746	−.23
025231	9349.5469	7	7.896	.021	9.460	.051	8	.49	.04	1.25	.09	1.564	.76
025482	9349.5348	4	6.565	.018	7.120	.019	3	.24	.03	.74	.03	.555	.50
026401	8941.7900	5	9.650	.017	10.538	.017	5	.75	.02	.93	.02	.888	.18
027174	9349.5682	5	8.558	.017	10.234	.024	6	.53	.02	.87	.03	1.676	.34
027386	9670.8134	3	6.059	.028	6.095	.028	4	.38	.05	.26	.05	.036	−.13
027424	8940.7983	2	9.163	.051	9.306	.051	4	−.14	.08	−.09	.08	.143	.05
027427	9669.7865	12	7.311	.026	9.912	.026	11	−.08	.04	.48	.04	2.601	.56
027524	9346.5577	4	9.364	.020	9.745	.020	4	.75	.03	.71	.03	.382	−.04
027526	9346.5772	4	10.803	.020	10.997	.020	4	.53	.03	.88	.03	.194	.35
027827	9349.5637	4	8.612	.019	9.864	.031	4	−.01	.03	.40	.04	1.252	.41
027922	9347.5607	9	7.542	.017	10.648	.017	9	.76	.02	1.66	.02	3.106	.90
027962	9670.8204	13	6.906	.027	9.178	.027	13	−.06	.04	.39	.04	2.272	.45
028165	9349.5824	3	8.351	.018	8.857	.019	6	.29	.03	.54	.03	.506	.25
028275	9347.5670	3	8.625	.017	8.746	.017	3	.33	.02	.37	.02	.121	.04
028383	9346.5898	4	9.516	.021	10.506	.024	4	.36	.04	1.84	.05	.990	1.48
028819	9346.5943	5	9.722	.021	11.362	.039	5	.83	.03	1.03	.06	1.640	.19
028852	9348.5975	4	8.257	.017	8.465	.017	3	.44	.02	.46	.02	.208	.02
029622	8939.8235	1	9.197	.020	10.326	.020	2	.73	.03	.70	.03	1.129	−.03
029811	9347.5776	5	7.069	.018	8.383	.028	5	.50	.03	.40	.04	1.314	−.09

Table 4. continued.

Identifier	Jul. Dat. 2440000+	n_V	V_{A} (mag)	$\sigma_{V_{\mathrm{A}}}$ (mag)	V_{B} (mag)	$\sigma_{V_{\mathrm{B}}}$ (mag)	n_I	$(V-I)_{\mathrm{A}}$ (mag)	$\sigma_{(V-I)_{\mathrm{A}}}$ (mag)	$(V-I)_{\mathrm{B}}$ (mag)	$\sigma_{(V-I)_{\mathrm{B}}}$ (mag)	ΔV (mag)	$\Delta\,(V-I)$ (mag)
030456	9349.6220	7	8.064	.017	9.801	.022	7	.41	.02	.46	.04	1.737	.05
030593	9348.6066	6	7.262	.017	9.039	.017	6	.15	.02	.39	.02	1.778	.25
030840	9349.6093	7	6.033	.028	7.448	.083	0	-	-	-	-	1.415	-
030925	9347.5830	6	7.038	.017	8.597	.019	6	.07	.02	.04	.03	1.559	–.02
031042	8940.8325	11	8.969	.054	10.402	.054	11	.62	.07	.87	.07	1.433	.25
031126	9345.6288	9	10.743	.020	12.678	.020	9	1.79	.03	2.46	.03	1.935	.67
031539	9346.6124	16	9.335	.020	11.931	.020	17	1.03	.03	.73	.03	2.596	–.30
031634	9345.6382	9	9.679	.020	12.772	.024	9	1.94	.03	.98	.04	3.093	–.96
031634	9345.6382	9	9.695	.020	12.526	.029	9	1.80	.03	2.89	.04	2.831	1.09
031833	8941.8389	11	11.598	.017	13.039	.018	0	-	-	-	-	1.441	-
032069	9347.5969	9	7.075	.017	9.183	.025	8	–.03	.02	.20	.04	2.108	.23
032111	9348.6281	11	8.021	.017	11.108	.056	11	.51	.02	1.53	.07	3.087	1.02
033177	8939.8370	10	9.569	.024	10.123	.024	10	.03	.03	.01	.03	.554	–.02
033487	9349.6266	4	9.716	.019	9.987	.021	3	.55	.03	.48	.03	.271	–.07
033499	9346.6570	4	10.649	.022	13.564	.027	0	-	-	-	-	2.915	-
033770	9348.6349	14	7.432	.017	10.032	.018	15	–.09	.02	.46	.03	2.600	.55
033900	9346.6613	4	8.811	.020	9.174	.020	4	–.04	.03	.09	.03	.362	.13
033969	9349.6428	14	8.223	.017	10.709	.022	13	.06	.02	.55	.03	2.486	.49
034000	9349.6484	4	5.814	.020	6.801	.030	4	–.31	.03	.12	.03	.987	.42
034386	9347.6434	11	8.065	.017	10.717	.023	11	–.13	.02	.60	.04	2.652	.73
034586	9349.6618	3	8.704	.019	9.540	.022	4	.33	.03	.45	.03	.836	.12
034817	9347.6500	11	6.075	.017	8.155	.027	11	–.14	.02	.11	.04	2.080	.25
034898	9348.6523	7	7.873	.017	10.132	.017	7	–.05	.02	.29	.02	2.259	.34
034919	9347.6839	14	7.456	.017	11.343	.084	1	.01	.02	.82	.09	3.888	.80
035207	8940.8604	5	8.174	.052	10.006	.052	5	.15	.07	.47	.07	1.833	.33
035391	9347.6614	3	7.641	.017	7.873	.017	1	–.12	.02	–.14	.02	.232	–.02
035439	9347.6665	11	7.926	.017	10.689	.020	10	.49	.02	.87	.03	2.763	.38
035539	9348.6767	1	8.304	.017	9.080	.018	3	–.02	.02	–.05	.03	.777	–.03
035924	9346.6712	4	10.361	.020	10.379	.020	4	.78	.03	.79	.03	.017	.01
036013	9349.6694	11	9.572	.017	11.274	.020	11	–.14	.02	.20	.03	1.702	.34
036108	9346.6759	4	10.161	.024	11.355	.043	4	.65	.03	3.35	.05	1.194	2.70
036442	9348.6946	5	8.811	.018	10.991	.044	11	1.19	.03	.38	.10	2.180	–.81
038137	9346.6847	4	8.977	.020	10.121	.021	4	–.67	.03	–.29	.03	1.144	.38
039290	9346.6884	4	8.203	.020	9.324	.020	4	–.17	.03	.17	.03	1.121	.35
039498	9346.7030	7	9.323	.021	10.688	.034	7	.74	.03	.84	.07	1.365	.10
043422	9345.7281	3	9.669	.020	9.959	.020	6	1.58	.03	1.72	.03	.290	.14
043539	9348.7327	4	7.400	.018	9.164	.025	1	.04	.02	.31	.03	1.764	.27
043708	9345.7341	3	12.019	.020	15.948	.051	3	2.61	.03	3.48	.06	3.929	.87
043920	9348.7458	3	7.262	.017	7.387	.017	3	.42	.02	.42	.02	.125	.00
044429	9349.7512	3	8.503	.017	11.550	.018	4	.27	.02	.68	.02	3.046	.41
044776	9347.7340	14	7.867	.017	10.735	.017	13	.09	.02	.70	.02	2.869	.62
045582	9349.7403	3	9.249	.017	9.689	.017	3	.68	.02	.73	.02	.440	.06
077311	8851.5231	11	8.743	.020	11.805	.020	10	.10	.03	.58	.03	3.062	.48
078163	8851.5294	2	9.058	.020	10.320	.021	3	.71	.03	.90	.03	1.262	.19
079960	8851.5429	3	8.392	.020	9.397	.020	3	.07	.03	.37	.03	1.005	.29
080540	8851.5703	3	10.508	.020	10.736	.020	3	1.27	.03	1.24	.03	.228	–.03
083530	8850.5728	16	9.886	.020	12.452	.020	17	.55	.03	.67	.03	2.567	.12
085306	8849.5645	5	9.409	.025	11.565	.025	6	1.05	.04	.45	.04	2.155	–.60
085685	8849.5822	12	8.962	.025	10.073	.025	0	-	-	-	-	1.111	-
086632	8852.5419	3	9.684	.020	9.918	.020	3	.66	.03	.69	.03	.234	.03

Table 4. continued.

Identifier	Jul. Dat. 2440000+	n_V	$V_{\rm A}$ (mag)	$\sigma_{V_{\rm A}}$ (mag)	$V_{\rm B}$ (mag)	$\sigma_{V_{\rm B}}$ (mag)	n_I	$(V-I)_{\rm A}$ (mag)	$\sigma_{(V-I)_{\rm A}}$ (mag)	$(V-I)_{\rm B}$ (mag)	$\sigma_{(V-I)_{\rm B}}$ (mag)	ΔV (mag)	$\Delta\,(V-I)$ (mag)
087176	8851.6328	14	10.288	.020	12.570	.020	15	.75	.03	1.24	.03	2.282	.49
087535	8852.5554	3	9.394	.020	10.374	.020	3	.60	.03	.70	.03	.980	.11
087718	8851.6572	13	8.861	.020	11.452	.020	13	1.20	.03	.73	.03	2.591	−.47
087914	8852.5610	3	8.677	.020	9.280	.020	3	.85	.03	1.12	.03	.602	.27
088203	8852.5766	6	9.209	.020	11.339	.020	6	1.11	.03	.65	.03	2.130	−.45
090189	8852.6030	3	10.215	.020	10.367	.020	0	-	-	-	-	.152	-
090574	8851.6638	3	8.130	.020	8.222	.020	6	.66	.03	.67	.03	.092	.01
090787	8852.6200	3	9.873	.020	10.214	.020	5	.48	.03	.55	.03	.342	.08
091380	8851.6781	9	8.174	.020	10.360	.020	3	.00	.04	.03	.04	2.183	.03
091754	8852.6250	4	8.536	.020	9.728	.020	3	.55	.03	.68	.03	1.193	.14
092415	8850.6263	12	8.283	.020	12.070	.020	13	.52	.03	.73	.03	3.787	.21
092560	8849.6048	14	9.421	.025	11.863	.025	14	.63	.04	.67	.04	2.441	.04
093069	8852.6397	3	9.383	.020	9.911	.020	3	1.87	.03	2.07	.03	.528	.19
093521	8849.6164	4	11.183	.025	12.465	.025	4	1.36	.04	1.82	.04	1.283	.46
093970	8852.7062	3	10.341	.020	10.478	.020	3	.70	.03	.71	.03	.137	.01
094307	8849.6550	11	9.776	.035	13.027	.035	14	.70	.04	1.29	.04	3.252	.58
095097	8850.6447	2	9.961	.020	11.336	.020	2	.40	.03	.62	.03	1.375	.21
095493	8852.6464	3	10.602	.020	10.629	.020	3	.49	.03	.50	.03	.027	.01
096667	8848.6367	4	7.426	.025	7.490	.025	5	.33	.04	.35	.04	.064	.02
096915	8850.6513	3	9.458	.020	10.398	.020	3	.83	.03	1.25	.03	.940	.42
097301	8848.6694	12	7.696	.025	10.543	.026	4	.38	.04	.84	.04	2.847	.47
097570	8850.6669	7	8.349	.020	10.791	.020	7	.07	.03	.44	.03	2.442	.38
097593a	8849.6674	3	6.958	.025	11.474	.026	3	1.03	.04	.79	.04	4.516	−.24
097593a	8852.6607	1	6.932	.021	11.526	.021	0	-	-	-	-	4.594	-
100182	8851.6862	13	10.152	.020	12.415	.020	14	.71	.03	1.32	.03	2.263	.61
101317	8852.7115	3	10.699	.020	10.756	.020	3	1.65	.03	1.67	.03	.057	.02
101653	8849.6992	4	8.999	.025	12.593	.026	20	1.17	.04	1.08	.04	3.594	−.09
102467	8852.7274	3	10.865	.020	13.726	.020	3	.66	.03	.69	.03	2.861	.03
102532a	8848.7300	3	4.264	.025	5.157	.025	4	1.04	.04	.60	.04	.893	−.44
103438	8852.7324	4	8.495	.020	8.983	.020	3	.59	.04	.86	.04	.488	.28
103475	8850.6935	4	9.640	.020	9.929	.020	1	.39	.03	.11	.03	.290	−.29
104370	8852.7473	3	10.264	.020	10.640	.020	3	.76	.03	.84	.03	.377	.08
104582	8850.7053	3	9.455	.020	10.930	.020	3	.43	.03	.50	.03	1.475	.06
105692	8851.7347	16	9.306	.020	11.165	.020	16	.73	.03	.81	.03	1.859	.08
105842	8851.7438	13	8.944	.020	11.817	.020	13	−.04	.03	.56	.03	2.873	.60
106411	8850.7115	4	10.135	.020	10.979	.020	4	.57	.03	.77	.03	.844	.20
106602	8850.7283	6	10.118	.020	11.327	.020	7	.87	.03	1.33	.03	1.209	.46
107206	8852.7558	3	10.660	.020	11.054	.020	3	.55	.03	.60	.03	.394	.05
107658	8850.7347	5	9.415	.020	10.915	.020	6	.65	.03	1.12	.03	1.500	.47
108801	8851.7629	8	8.215	.020	9.975	.020	8	.35	.03	.57	.03	1.760	.21
109183	8851.7685	4	8.957	.020	10.183	.020	3	.71	.03	.94	.03	1.226	.23
109840	8851.7854	6	8.634	.020	10.622	.028	6	.26	.03	.67	.04	1.989	.41
110654	8939.5889	4	9.692	.022	11.248	.022	4	.14	.04	.39	.04	1.556	.25
111231	8941.5226	4	9.490	.015	11.246	.015	4	.60	.02	.88	.02	1.757	.29
111687	8852.7945	10	9.630	.020	12.273	.020	10	.63	.03	.58	.03	2.643	−.05
113386	9670.5303	9	7.679	.025	9.286	.025	10	.75	.04	.81	.04	1.607	.06
113537	8850.8008	6	8.232	.020	9.506	.020	6	.57	.03	.68	.03	1.274	.11
114167	8848.8258	3	6.297	.025	7.100	.025	5	.55	.04	.61	.04	.803	.06
114378a	8850.7841	3	6.543	.020	10.275	.021	1	.60	.03	1.56	.03	3.731	.97
114857	8852.8049	14	8.791	.020	11.541	.021	14	.88	.03	.65	.03	2.750	−.24

Table 4. continued.

Identifier	Jul. Dat. 2440000+	n_V	V_A (mag)	σ_{V_A} (mag)	V_B (mag)	σ_{V_B} (mag)	n_I	$(V-I)_\mathrm{A}$ (mag)	$\sigma_{(V-I)_\mathrm{A}}$ (mag)	$(V-I)_\mathrm{B}$ (mag)	$\sigma_{(V-I)_\mathrm{B}}$ (mag)	ΔV (mag)	$\Delta\,(V-I)$ (mag)
115863	8852.8251	6	8.872	.020	10.610	.021	3	.31	.03	.41	.03	1.738	.10
116068	8850.8134	5	9.311	.020	10.909	.020	6	.51	.03	.60	.03	1.599	.09
116737	8848.8578	4	6.628	.039	7.405	.039	4	.30	.05	.40	.05	.777	.10
116748	8852.8310	4	8.503	.020	9.710	.020	4	.77	.03	1.10	.03	1.206	.34
117081	9668.5409	6	9.697	.021	9.789	.021	4	.64	.03	.66	.03	.092	.02
117269	8941.5436	5	9.410	.016	9.468	.016	6	.47	.02	.47	.02	.057	–.01
117598	8941.5616	14	8.873	.016	11.375	.017	15	.60	.02	.82	.02	2.502	.23
ADS6223	9345.6941	6	9.011	.017	10.387	.017	9	.14	.02	1.90	.03	1.376	1.76
042581a	9345.6621	3	7.738	.020	9.910	.025	0	-	-	-	-	2.172	-
–1504995a	8850.5992	3	9.475	.020	9.506	.020	0	-	-	-	-	.031	-
032144a	9347.5462	3	6.256	.017	8.367	.017	3	.32	.02	.71	.03	2.111	.39
032144a	9348.5582	6	6.245	.017	8.356	.017	7	.32	.02	.66	.02	2.111	.35
005843a	8851.9178	3	7.536	.020	11.881	.026	0	-	-	-	-	4.345	-
005843a	8852.8897	3	7.534	.020	11.870	.022	0	-	-	-	-	4.336	-
005843a	9345.4642	3	7.027	.020	11.259	.022	0	-	-	-	-	4.231	-
005843a	9347.4026	3	7.623	.017	11.886	.017	3	2.15	.02	.70	.03	4.263	–1.45
005843a	9349.4065	3	7.621	.017	11.891	.018	3	2.17	.02	.76	.03	4.270	–1.41
000248a	9346.4267	5	8.467	.020	9.564	.020	3	.20	.03	.75	.03	1.097	.55
+1303203a	8848.5108	3	9.099	.032	9.595	.033	2	.75	.04	.84	.04	.496	.08
+1303203a	8849.4945	3	9.071	.025	9.564	.025	3	.73	.04	.80	.04	.493	.07
+1303203a	8850.5132	6	9.072	.020	9.567	.020	9	.75	.03	.83	.03	.496	.08
+1303203a	8851.4831	5	9.101	.020	9.593	.020	3	.75	.03	.83	.03	.491	.08
+1303203a	8852.4996	3	9.092	.020	9.574	.020	0	-	-	-	-	.482	-

about 5″ (Fig. 3). We tried to find some explanation for this. For example, we have verified that the effect is:

– independent from the observer;
– not correlated with seeing or differential refraction;
– not due to a bad focusing in one of the filters in a systematic way;
– not correlated with the colour difference of the two components.

Therefore we did not introduce any correction. This will be checked further in the results of other campaigns.

6.2. External errors on the astrometry

Some programme and astrometric standard stars were observed twice or more (see Table 3). As mentioned before, these regularly observed double stars are important to check the consistency between observations obtained at different epochs. There is indeed an excellent agreement between the measurements of the same star as can be deduced from the small standard deviations both in angular separation and in position angle. For example, we can check the wide astrometric pairs with observations obtained at different epochs: BD +13°3203 (+1303203a, $n = 5$), BD –22°1505 (32144a, $n = 4$), BD –56°256 (5843a, $n = 7$) in Table 3. Their standard deviations fluctuate between 0.003 to 0.005″ in angular separation and between 0.01 to 0.02° in positional angle.

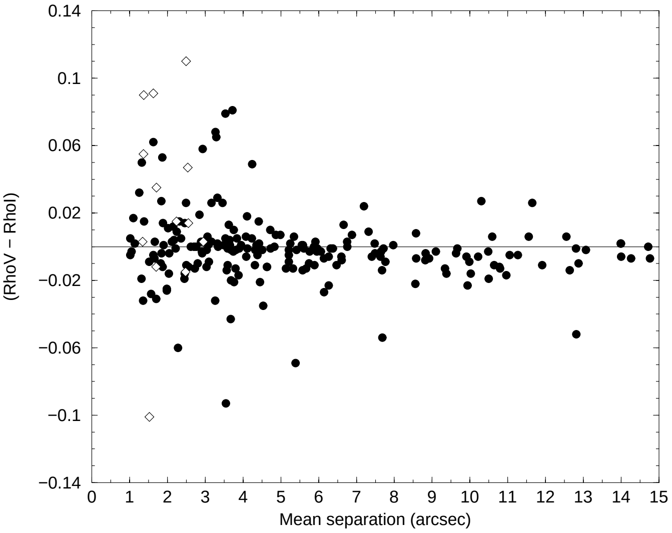

Fig. 3. Differences in angular separation between filters V and i. Unfilled diamonds represent the 15 systems with $\rho < 3''$ and $\Delta i > 2$ mag.

6.3. Internal errors on the photometry

We discuss here both internal errors: those on the differential photometry only and those of the absolute photometry (obtained through calibration of standard stars). In the former case, the internal photometric errors depend on the repeatability of the differences of the component

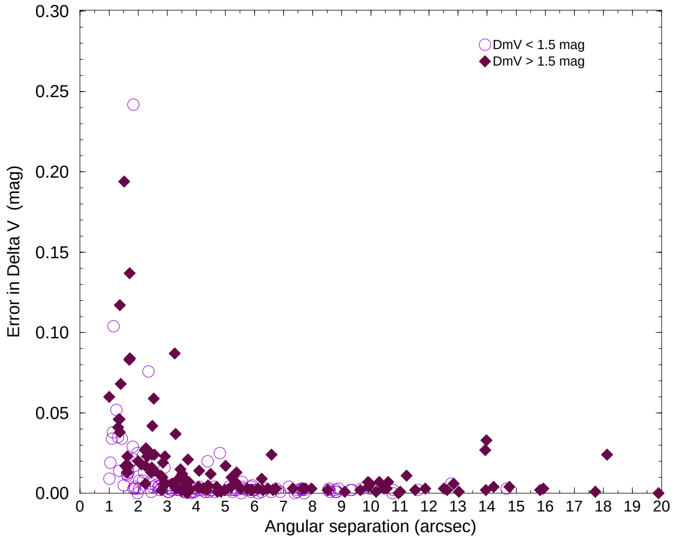

Fig. 4. Internal errors on mean differential V magnitude vs. angular separation for two classes of Δm.

magnitudes. The internal consistency of these differences can be assessed by inspection of the standard deviations listed in Table 3. Figure 4 represents the distribution of the internal errors on the differential V magnitude plotted as a function of angular separation for two different ranges of ΔV. The mean internal error is well below 0.01 mag but there is evident degradation at larger differential magnitudes. In the worst case of a combination of a small separation ($\rho < 3''$) and a large difference of magnitude ($\Delta V > 2$ mag), this error tends to increase to a few tenths of a magnitude. A similar figure applies to the differential I magnitudes.

The multiply observed astrometric standard stars BD +13°3203 ($n = 5$), BD –22°1505 ($n = 4$) and BD –56°256 ($n = 7$) from Table 3 show the same tendency: we find millimag consistency on the differential magnitudes in the case of BD +13°3203 ($\Delta V < 1$), some hundreths of a magnitude for $1 < \Delta V < 4$ and more than 0.1 mag in the case of BD –56°256 ($\Delta i > 5$) shown hereafter to be variable.

In the latter case – under favourable photometric conditions – several standard stars have been observed to which classical colour equations have been applied. We have taken into consideration a transformation error (generally 0.02–0.03 mag) depending on the quality of each night as well as an error (usually insignificant) on the joint magnitude of the system to compute the individual errors on the component magnitudes which are also listed in Table 4 (Paper I, Sect. 4.3).

The mean errors on the magnitudes and the indices $(V-I)$ of the components A and B deduced from Table 4 respectively give the following values: $\sigma_{V_\mathrm{A}} = 0.006$, $\sigma_{V_\mathrm{B}} = 0.009$, $\sigma_{(V-I)_\mathrm{A}} = 0.009$ and $\sigma_{(V-I)_\mathrm{B}} = 0.024$ mag. For the sample of binaries with $\rho < 3''$ and $\Delta m \geq 2$, these values rise to $\sigma_{V_\mathrm{A}} = 0.020$, $\sigma_{V_\mathrm{B}} = 0.027$, $\sigma_{(V-I)_\mathrm{A}} = 0.027$ and $\sigma_{(V-I)_\mathrm{B}} = 0.041$ mag.

Table 5. CCD I photometry for 4 Hipparcos and 1 astrometric standard double stars.

Identifier	Jul. Dat. 2440000+	n_I	I_A (mag)	σI_A (mag)	I_B (mag)	σI_B (mag)	ΔI (mag)
005843a	9348.4085	3	5.904	.017	11.173	.061	5.269
079902	8851.5582	16	7.816	.020	10.801	.020	2.985
088603	8850.6143	13	8.658	.020	10.720	.020	2.062
109156	8850.7526	4	9.102	.020	12.706	.020	3.604
117316	8850.8339	11	9.647	.020	12.601	.020	2.954

6.4. External errors on the photometry

External photometric errors can be evaluated from observations of the same target acquired during different nights or different campaigns. For this we consider the multiple observations of some astrometric standard stars (BD +13°3203 (+1303203a, $n = 5$), BD –22°1505 (32144a, $n = 2$), BD –45°13443 (97593a, $n = 2$)) as well as some programme stars (HIP 2438, HIP 20020) listed in Table 4. In addition, we also consider the objects in common with Paper II (see Table 6). The case of BD –56°256 (5843a, $n = 5$) is not included since we note significant variations between individual measurements as well as a difference of 0.1 mag between our measurements and those reported in Paper II. This confirms the variability detected by Hipparcos for this red giant of spectral type M2/3III. Taking into consideration the nine objects previously cited, we find $\sigma_{V_\mathrm{A}} = 0.025 \pm 0.029$ and $\sigma_{V_\mathrm{B}} = 0.032 \pm 0.037$ mag. If we remove only one star (HIP 20020) we obtain $\sigma_{V_\mathrm{A}} = 0.016 \pm 0.012$ and $\sigma_{V_\mathrm{B}} = 0.017 \pm 0.021$ mag. We thus are confident that the errors quoted in Table 4 are very realistic upper limits.

6.5. Comparison with ground-based photometry

We searched existing data bases for component photoelectric photometry. We have systematically searched in the UBV, Strömgren and Geneva photometries since these systems have the highest probability of success. Apart from the component photometry of the Double and Multiple Systems Annex (vol. 10 of the Hipparcos Catalogue, ESA 1997), we found individual information for 11 primary and 5 secondary components of our sample only making use mostly of the Lausanne Photometric data base (Mermilliod et al. 1996) and for some systems of the Besançon Double and Multiple Star data base (Kundera et al. 1999). In Figs. 5 and 6 we illustrate the comparison as a function of angular separation and magnitude difference: HIP 3397 ($\rho \simeq 14''$ and colours of a giant) has a small deviation for the primary but a large difference (>0.1 mag) for the secondary component; the primary component of HIP 9258 ($\rho \simeq 9''$) turned out to be a variable star (a discordant previous measurement had mistakenly been attributed to the B companion) so the

Table 6. Comparison of CCD VI photometric observations: our data (LO) versus Cuypers & Seggewiss (1999) (CS).

Identifier	Jul. Dat.	n_V	V_A	σ_{V_A}	V_B	σ_{V_B}	n_I	$(V-I)_\mathrm{A}$	$\sigma_{(V-I)_\mathrm{A}}$	$(V-I)_\mathrm{B}$	$\sigma_{(V-I)_\mathrm{B}}$	ΔV	$\Delta(V-I)$	Code
011219	9668.7130	10	8.864	0.020	10.129	0.020	0	-	-	-	-	1.265	-	LO
011219	8549.7389	4	8.842	0.016	10.132	0.016	4	0.969	0.017	0.630	0.021	1.290	–0.340	CS
022463	8941.7542	3	8.958	0.015	9.763	0.016	2	0.51	0.02	0.64	0.02	.805	0.13	LO
022463	8550.7998	6	8.960	0.014	9.770	0.014	3	0.539	0.017	0.661	0.017	0.810	0.122	CS
042581a	9345.6621	3	7.738	0.020	9.910	0.025	0	-	-	-	-	2.172	-	LO
042581a	8671.6577	6	7.712	0.016	9.933	0.024	3	0.734	0.018	0.734	0.027	2.221	0.000	CS
114378a	8850.7841	3	6.543	0.020	10.275	0.021	1	0.60	0.03	1.56	0.03	3.731	0.97	LO
114378a	8548.6123	16	6.572	0.011	10.276	0.020	13	0.594	0.019	1.564	0.017	3.704	0.970	CS

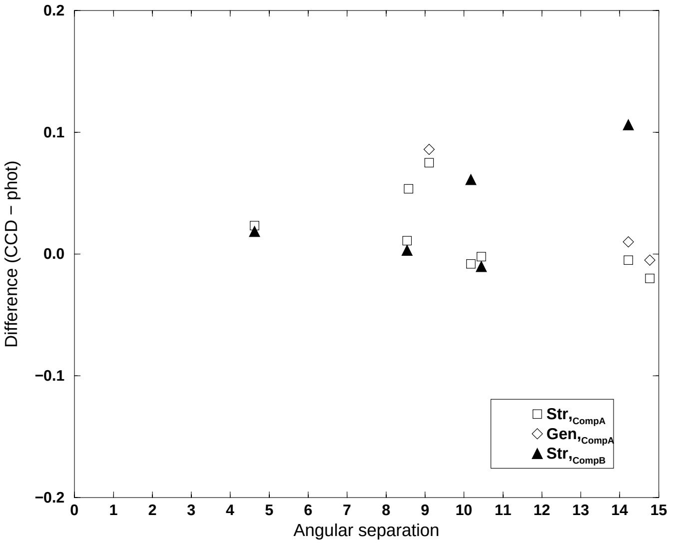

Fig. 5. Difference between V *component* magnitudes in the sense CCD minus photoelectric versus angular separation.

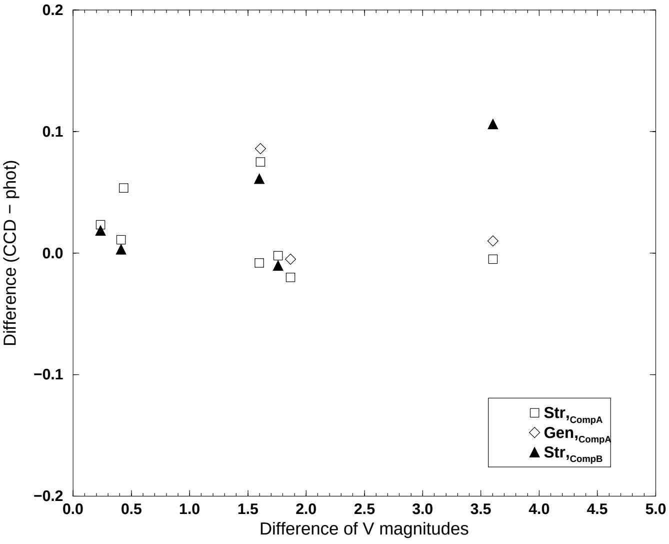

Fig. 6. Difference between V *component* magnitudes in the sense CCD minus photoelectric versus differential magnitude.

deviation of 0.05 mag is not surprising. Except for HIP 113386 ($\rho \simeq 9''$) where both Strömgren and Geneva values are off by as much as 0.08 mag (no reason found); the same effect is also seen on the difference between the joint V Johnson and CCD magnitude), the agreement is excellent for the primaries, with a mean deviation of +0.006 mag and a scatter of 0.022 mag only. In general the agreement is really good for the primary star but worse on the secondary component. The published mean error is of the same order as the scatter found in the differences between the CCD and the photoelectrically measured component magnitudes (≃0.02 mag). Even though the data are few, there is a possible trend when one considers both figures together: the discrepancies are more frequent at large separations and large differences of magnitude.

More comparison data are available for the combined photometry of these systems: 122 double stars have either UBV or Strömgren or Geneva combined photometry. We have 62 common pairs with Johnson, 70 with Strömgren and 64 with Geneva photometry. Total CCD magnitudes have been recomputed from standard component magnitudes. A histogram of the differences is shown in Fig. 10 where the gray zone refers to the differences with the Strömgren photoelectric photometry. After removal of the "outlier" cases at the 3-σ level for which the differences are larger than 0.1 mag in absolute value (including 10 different objects), the mean deviations and scatters are:

- for 58 CCD minus Johnson V magnitudes: (+0.0097, 0.033);
- for 63 CCD minus Strömgren y magnitudes: (+0.0090, 0.036);
- for 61 CCD minus Geneva V magnitudes: (+0.0118, 0.031).

Consistent features are a mean difference of +0.01 mag, slightly more pronounced for the Geneva system, and a scatter of 0.03 mag that perfectly matches the abovecited error distributions. In contrast to Paper II, we detect a small systematic difference of ≃0.01 mag in the sense that our CCD magnitudes tend to be somewhat fainter than the photoelectric ones, even though it must be said that our errors are a little bit larger (due to different photometric conditions). Following the same reasoning as in the former paper, if we adopt a mean error of 0.02 mag for

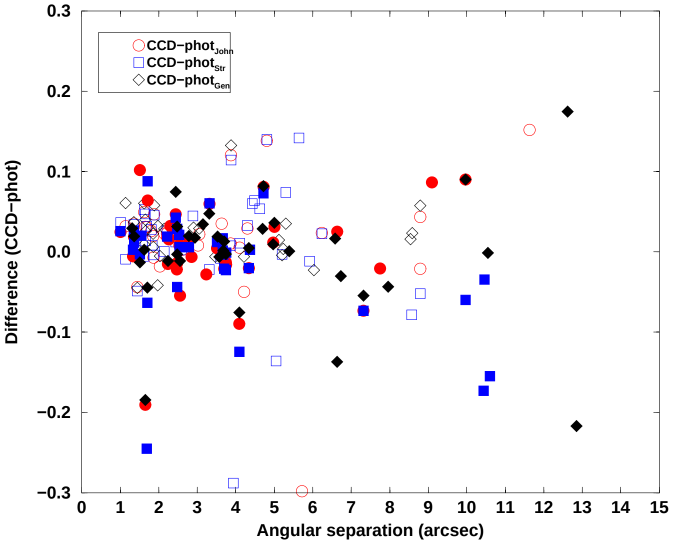

Fig. 7. Difference between total $V_{\mathrm{A+B}}$ magnitudes in the sense (CCD minus photoelectric) versus angular separation for two classes of Δm (filled symbols are used for $\Delta V > 1.5$ mag).

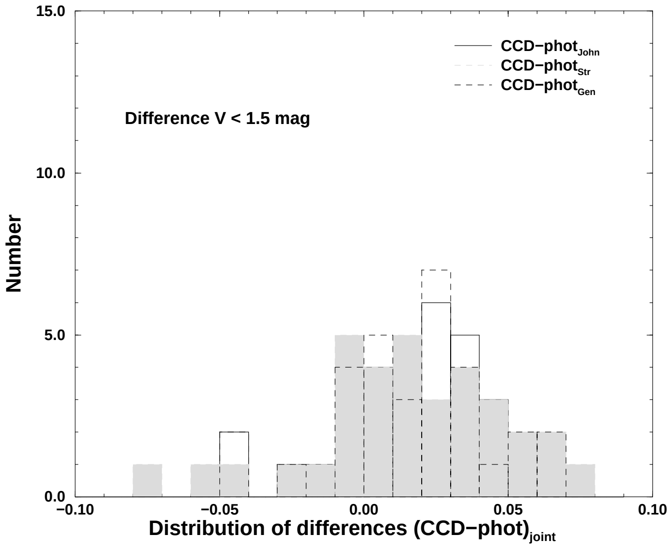

Fig. 8. Histogram of differences between total $V_{\mathrm{A+B}}$ magnitudes in the sense (CCD minus photoelectric) for $\Delta V < 1.5$ mag only.

the photoelectric magnitudes, we find a typical error of 0.025 mag for our *combined* CCD magnitudes. This shows that our CCD *component* magnitudes are generally reliable to within much better than 0.03 mag and successfully competing with precise photoelectric photometry.

Figures 7 and 9 again illustrate the differences in the sense CCD – photoelectric, this time as a function of separation and differential magnitude. The distribution of the differences in these figures does not look as expected from our previous considerations: several large deviations can be noted. However, different effects are in play here and we will discuss each one in turn.

Let us first consider the largest differences found a) at values >0.1 mag and b) at values <−0.1 mag.

In Figs. 7 and 9, from the nine values > 0.1 mag, two are flagged by larger errors than usual in the CCD data (HIP 10722 (red giant), 31042). One is clearly wrong (HIP 110654; $\rho = 12.6''$). The remaining data show no problem of data reduction and concern three systems with separations between 4 and 6″ (HIP 13199, 85685, 116737). We do not discard that the reason of this discrepancy could lie in our CCD data.

From the 12 cases with values <−0.1 mag (only nine plotted between −0.1 and −0.3 mag in Fig. 9), one has a flag indicated by larger errors than usual in the CCD data (HIP 13815; $\rho = 1.7''$), one has a separation very close to the seeing limit (HIP 33499 with red colours has $\rho = 1.7''$). From the remaining cases, three have separations at or larger than 10″. Although no immediate explanation can be found for the other cases (HIP 20020, 23480, 26401, 31833, 34898 and 93521) with separations between 3 and 7″, we are confident that the reason does not lie in the CCD data but in the way how photoelectric photometry was performed on these systems: joint photoelectric magnitudes are fainter because part of the light of both components is lost when measured in a diaphragm too small for the given pair separation. This effect is found to be most pronounced when the companion has Δm around or larger than 1 mag and for separations which are significant compared to the used diaphragm size. This may be the cause for the important negative deviations noted for double stars with separations above ≃5″.

Next we discuss the gross of the data with differences situated between −0.1 and 0.1 mag in both figures. We have seen that the general agreement is of order 0.02–0.03 mag. This is reflected by the scatter in the data with $\Delta V < 1.5$ mag which appears to show a bimodal distribution centered on two values: ≃0.00 mag (Strömgren system, to a lesser extent Geneva system) and ≃0.03 mag (Johnson and Geneva systems, to a lesser extent Strömgren system) in the histogram presented in Fig. 8 (whereas this effect was seen only in the differences with the Geneva photometry (Paper II)). If we now consider the region with $\Delta V > 1$ mag in Fig. 9, we see a tendency of larger negative deviations in the range $1.5 < \Delta V < 3$ mag associated with angular separations above 5″. The same effect plays a role in the few cases having $1.5 < \Delta V < 3$ mag and $\rho > 6''$ in Paper II: it can be explained by the loss on the system's total light when the two components are simultaneously measured in a diaphragm whose size is about the size of the system's angular separation (Oblak et al. 1997).

We thus repeat that 0.03 mag is a conservative upper limit of the mean error of the CCD V magnitudes.

7. Conclusions

As already stated before, the usage of a 1m telescope equipped with a professional CCD camera allows to obtain high quality relative astrometric data on double stars. Mean errors are 0.01″ in angular separation and 0.07° in position angle. This has been obtained by applying a strict

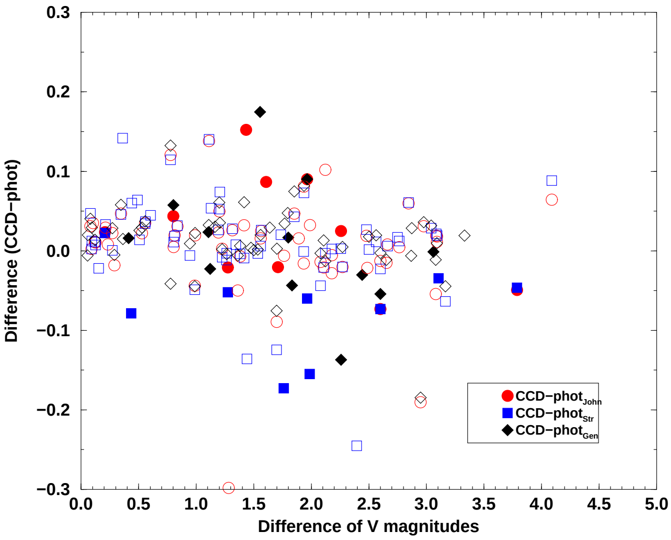

Fig. 9. Same data as in Fig. 7: difference between total $V_{\mathrm{A+B}}$ magnitudes in the sense CCD minus photoelectric versus differential magnitude for two classes of ρ (filled symbols are used for $\rho > 6''$).

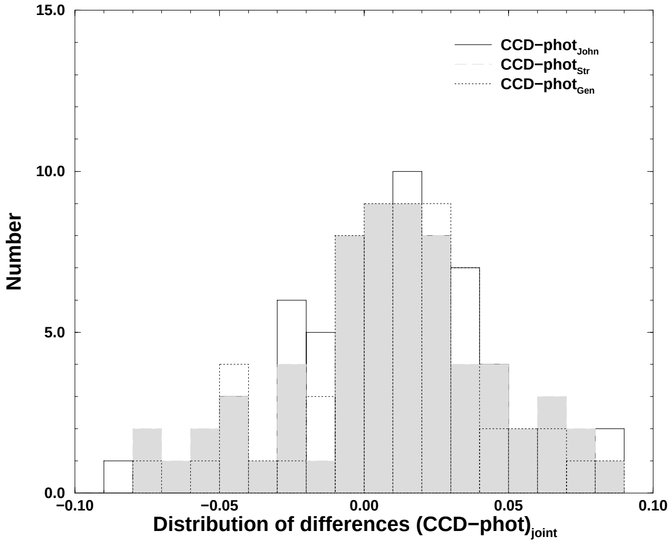

Fig. 10. Histogram of differences between total $V_{\mathrm{A+B}}$ magnitudes.

observational protocol throughout the various campaigns, notwithstanding many instrumental changes.

We have obtained for a large sample of double stars observed in an all-sky mode standard V and I magnitudes as well as $(V-I)$ colour indices with precisions in the instrumental system of 0.006 and 0.009 mag respectively for the brightest companion and 0.009 and 0.024 mag for the faintest one. Accuracies (external errors obtained through comparison) are generally below 0.03 mag but degrade quickly for the smallest separations observed ($\rho < 3''$).

Comparison of our data with the photoelectric photometry in the UBV, Geneva and Strömgren systems shows a systematic difference of one hundredth of a magnitude on the total V magnitudes. The same comparison illustrates very well the degradation (higher scatter of the differences) coupled with larger angular separations and the larger differential magnitudes. For systems with angular separation between 5$''$ and 12$''$, CCD photometry appears to be more adequate than photoelectric photometry: systematic effects appear due to the chosen diaphragms which are generally too small with respect to the observed separations and magnitude differences. For systems of even smaller separation and with almost equally luminous components, we found another (small) systematic effect for which however we still have no explanation. This effect implies that total V magnitudes are slightly fainter when measured with CCD photometry than with photoelectric photometry.

The measurement of the difference $\Delta(V-i)$ is an efficient tool to detect subgiant or giant companions among double stars. The analysis of the colour differences shows that 40 systems have a negative $\Delta(V-i)$. From these, 17 out of 23 systems with known spectral types and with $\Delta(V-i) < -0.1$ may be in an advanced stage of evolution, i.e. 74% comprise a subgiant or giant primary component. Such systems are of particular astrophysical interest and deserve further attention.

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